MAY 1950

Journal

VOL. 42 • NO. 5

AMERICAN WATER WORKS ASSOCIATION

In this issue


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Journal A.W.W.A. is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 500 Fifth Ave., New York 18, N. Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918.

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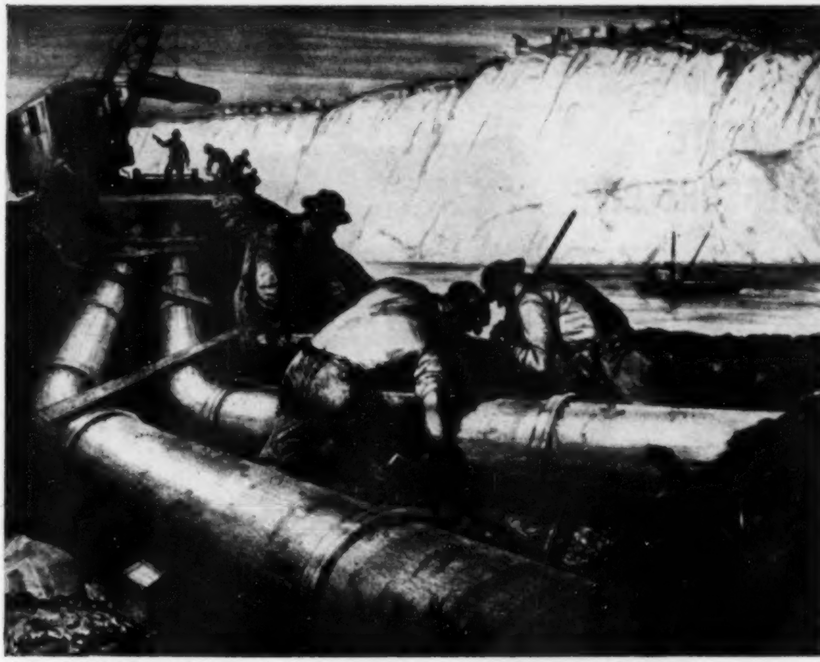

Lithographed on stone by James E. Allen

COMING MEETINGS

A.W.W.A. 1950 ANNUAL CONFERENCE

Philadelphia, Pa.

May 21–26

Reservation forms have been mailed to all members, and all reservations will be cleared through the A.W.W.A. office. The hotels have agreed to accept no reservations for the 1950 Conference except as they are requested on the standard form prepared by the A.W.W.A.

Accommodations at Twelve Hotels

All Technical Sessions and Exhibits at Convention Hall

May **11–13**—Pacific Northwest Section at Hotel Winthrop, Tacoma, Wash. Secretary: Oscar P. Newman, Boise Water Corp., Boise, Idaho.

June **29**—New Jersey Section Clambake and Outing, Germania Park, Dover. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.

Journal

AMERICAN WATER WORKS ASSOCIATION

Vol. 42 • No. 5

May 1950

Contents

Departments

Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*.
Microfilm edition (for Journal subscribers only) by University Microfilms, Ann Arbor, Mich.

All correspondence relating to the publication of papers should be addressed to:

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$7.00 of members' dues are applied as a subscription to the Journal; additional single copies to members—50 cents; single copies to non-members—75 cents.

W. Victor Weir, President 1950–1951

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 42 • MAY 1950 • NO. 5

Water Works Industry—Healthy or Anemic?

By Louis R. Howson

A paper presented on April 4, 1950, at the Canadian Section Meeting, Niagara Falls, Ont., by Louis R. Howson, Partner, Alvord, Burdick & Howson, Chicago.

WILLING Water, the now familiar symbol of the water works industry, is a real work horse. If he is to continue to be able to perform his duties and to meet the ever increasing demands for more service, he must be provided with the food which gives him the energy required. That food is dollars, in an amount sufficient to maintain the physical structure and provide for its orderly growth. A horse cannot develop on a deficient diet. Neither is it possible for Willing Water to perform adequately the services expected from him and to broaden his usefulness further, unless he is provided with the sustaining revenues.

Some water works operators are deceived by the fact that their utilities are enjoying a net revenue in dollars equal to or greater than any previously experienced. But today's dollars have only approximately half the purchasing power of prewar dollars. Therefore, the actual net income, as measured by what it will purchase in new construction, is only about one-half of what it formerly was. It is no more possible for a water works to sustain a healthy development on the same number of dollars (now worth 50¢) as it formerly had than it is for a horse to thrive on the same volume of feed which, through the operation of inflationary costs, has gradually been reduced from 100 per cent oats to 50 per cent oats and 50 per cent sawdust. Such a diet is fatal to a horse and such a stretching of the dollar will certainly stifle the service which water utilities can perform. Starvation is not in the interest of either the owner or those who use the service. This applies equally to horses or utilities.

Effect of Inflation

At present approximately four-fifths of all North American water utilities are publicly owned, but economic laws affect publicly and privately owned water works alike. For both types, the ability to survive, serve adequately and expand as needed depends, in the final analysis, on the adequacy of the revenue derived from furnishing the service.

The charges for water service in most publicly owned plants can be adjusted by the governing body. Any deterrent to allowing the water utility adequate revenue is usually political—the belief that increasing rates is not popular or politically expedient. In Chicago, for example, much needed filtration cannot be financed without a rate increase. Those in charge hesitate to impose one even though a rise as great as 50 per cent would cost two-thirds of the city's families less than 1¢ each per day. It would appear that, since trolley fares have been increased 7¢ per ride, 1¢ a day per family would be a cheap price to pay for filtered water instead of a heavily chlorinated, safe, but frequently turbid, product.

Private utility rates are usually regulated by commissions. For 50 years utilities were generally allowed to earn a fair return on "fair value." During that period capital additions to water works increased at a rate 2½ times as rapid as the population growth. Service became the best in history and in the world. Under the "fair value" theory, the utilities' revenues tended to keep pace with the changing value of the dollar.

Since costs have risen so rapidly, as the result of World War II, some commissions have turned to "original cost" as the rate base. If the same rate of return is allowed as before the war, the utility receives the same number of dollars as it did then and can buy only half as much with them, while the purchasing power of its return to the stockholders is also cut in half. The net results will inevitably be inability to finance new construction requirements and, thus, an anemic utility.

Value is a measure of future usefulness. A water works seeking adequate rates has to furnish the service, collect its revenues under the new rates, and expend for operation, maintenance, taxes and return to investors the money to be collected in the future. Rates must necessarily reflect that fact if they are to be equitable. Six per cent return on yesterday's cost will not finance tomorrow's requirements.

Revenue and Expenditure

In 1947 the author presented a paper on adjusting rate structures to meet rising cost levels (1). In preparing that discussion, the operating statistics of a group of 100 water works, serving a total population of about 9,000,000 (10 per cent of the North American urban total), were secured and analyzed for the period 1941–46. During that period, because of the all-out war effort, the maintenance expenditures of utility properties were pared to the bone and other than the most essential construction was deferred. Also, during the war period the costs of most materials and, to a considerable extent, the cost of labor were either frozen or controlled at levels below what they would have been without such action.

The effect of the above factors was that during the war period the relation of operating costs to gross revenues remained substantially stationary and, in the 100 plants studied, was approximately 50 per cent. The year 1946, however, saw the release of many controls and the full release of restrictions on wages, at least in the United States. With the taking up of the slack in maintenance and the resumption of construction, the operating ratio of expenses to revenues rose sharply and the costs of materials needed for new construction likewise jumped.

In connection with the present paper, it has not been possible to collect and study the operating statistics of the 100 utilities previously mentioned. Comparable records, however, have

been studied for a smaller group of cities, with a total population of about 2,500,000. The data for these cities, which were all included in the original study, are available for the years 1946 through 1949.

The smaller group of plants studied had an operating ratio (ratio of expenses to revenues) of 46.7 per cent in 1946, compared with 54.2 per cent for the 100-plant group in that year. The ratio for the smaller group increased to 50.8 per cent in 1947, 51.5 in 1948 and 53.8 in 1949. In Fig. 1, these data have been used as a basis for projecting the 100-plant curve from 1946 to 1949. The resulting 1949 operating ratio for

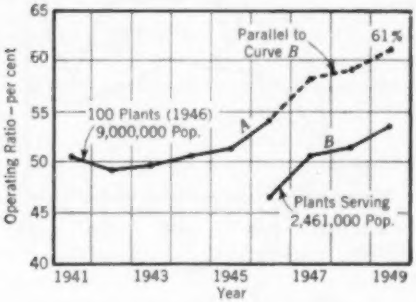


FIG. 1. Operating Ratios, 1941–49

the 100 plants is approximately 61 per cent. In other words, although before and during the war 50 per cent of the gross revenue was available for fixed charges, taxes, depreciation and new construction, only 39 per cent was left in 1949.

In 1945 the average gross revenue per customer in the 100 water works was $32.10; in 1946 the plants herein studied had a gross revenue per customer of $33.90, which increased to $36.50 during 1949. The annual operating expense before taxes and depreciation of the properties now studied has increased $3.30 per customer from 1946 to 1949, so that the actual net before taxes has decreased from $17.70 in 1946 to $16.90 in 1949 (about 5 per cent). These figures compare with $14.65 net per customer before depreciation for the 100 plants in 1945.

Prior to the war the water systems used approximately 50 per cent of their gross revenues for operation and maintenance, 25 per cent for fixed charges and 25 per cent for new construction. With a 61 per cent operating ratio in 1949, the net per customer would be about $14.25 (3 per cent less than the $14.65 figure for 1945). For

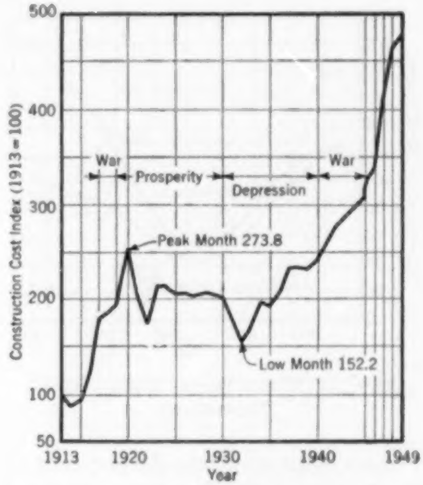


FIG. 2. Construction Cost Index, 1913–49

all practical purposes, the growth in revenues has substantially paralleled the increase in operating and maintenance costs. If it is assumed that fixed charges have remained constant, the amount available for plant expansion has also remained constant at about $7.35 per customer per year. But that amount will build only about half as many mains, filtration plants and the like as in 1940. The other $7.35 per customer must come from increased revenues.

No water works is ever static. It is

just as much the obligation of the management to provide the funds necessary for orderly expansion and development as it is to maintain and operate the property. The money for that development can be secured, directly or indirectly, only from the water works revenues. Where construction can be currently financed without borrowing, experience has shown that method to be the best and cheapest. Financing in advance from earnings results in savings of approximately 40 per cent in capital and interest over a long period.

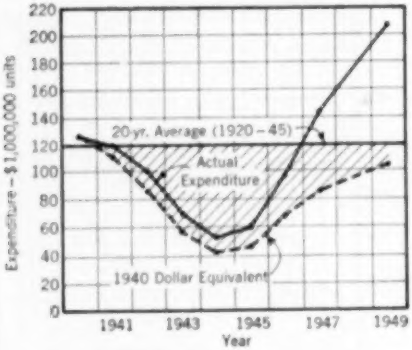


Fig. 3. Water Works Construction Expenditure

Since approximately 25 per cent of the revenue dollar has been expended for new construction in the past, and since the cost of all construction work has greatly increased in the postwar period (and, judging from other wars, will never again materially decrease) it is important to keep up to date on how much construction the dollar will buy. Probably the most generally recognized index of construction cost is that compiled by the *Engineering News-Record*. Figure 2 shows that index in graphical form from 1913 through 1949, with 1913 taken as 100.

In the period 1925–45 the water works of the United States spent an average of $120,000,000 a year for new construction. Beginning with 1941 construction was necessarily curtailed. The volume of water works construction from 1940 through 1949 is shown in Fig. 3. In this period, however, the *dollars* spent for new construction do not fairly represent the *volume* of construction which could have been purchased for the same expenditure at prewar cost levels. Therefore, the prewar dollar equivalent of actual expenditures since 1940 has also been plotted. It is apparent from this diagram that,

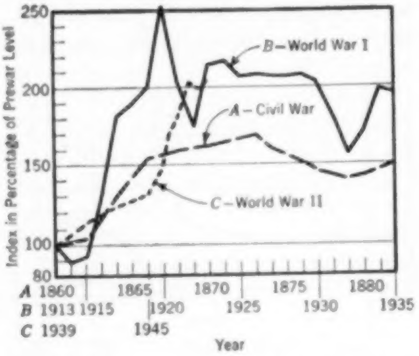


Fig. 4. Effect of Wars on Construction Cost and Wage Indexes

although $207,000,000 was spent in the United States for water works construction in 1949, the volume of construction was still below the average for the two prewar decades.

This accumulated deficiency, shown by the shaded area in Fig. 3, was equivalent at the end of 1949 to more than three years of normal prewar construction in the water works industry. At present prices, it will require the expenditure of $750,000,000 to bring water works facilities abreast of the point they would have reached had there been no war. Instead of spending $120,000,000 a year for new construction as in the prewar period, $200,000,000 to

$250,000,000 must now be expended. and to recover the ground lost during the ten-year war period, the total capital expenditures for water works must average $300,000,000 annually over the next decade. That will require an increase in revenue of about $2.25 per capita, or 35 per cent.

It is important to bear in mind that facilities, not dollars, furnish water service, and it is the ability to maintain the growth in facilities that determines whether or not water works are adequately meeting their present and future obligations. Unless the growth in facilities is at least equal to the requirements, the water works industry is not in a healthy condition.

Cost Trends

Water revenues have to be collected in the future at the rates effective in the future to pay for all construction executed in the future. Provision for needed funds must accordingly be made before rather than after the construction proceeds. Consequently, it becomes essential to anticipate the dollars required to finance adequately the construction found necessary in the future. All engineering work by nature involves a forecast. As it is physically impossible to build any structure in the past, the cost of every project must be estimated in advance, and the financing likewise. In this respect, the engineering profession differs radically from the legal profession, which is largely based on precedent. The difference was illustrated by a lawyer who said that he "always liked to work with engineers. Engineers and lawyers always stand back to back, with the engineer facing forward."

Every war is followed by a spending spree. Costs rise sharply and eventually recede somewhat but never again fall to the prewar level. Experience during and after the Civil War and World War I indicates that construction costs will never be less than 50 per cent above what they were in 1940. At that time the *Engineering News-Record* construction cost index was about 240. At the time of writing, it was approximately 480. Figure 4 compares the labor cost trend following the Civil War with the construction cost trends after World Wars I and II. The close

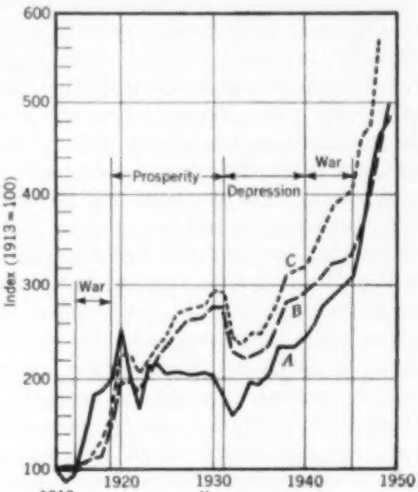


FIG. 5. Wage Rates and Construction Costs
A—E.N.-R. construction cost index (1913 = 100)
B—Hourly wage rate, all building trades (1913 = 100)
C—Hourly wage rate, laborers and helpers (1913 = 100)

relationship is apparent. The ratio of 1949 construction costs to those of 1939 is almost identical with the ratio of postwar to prewar costs in 1923, ten years after the start of World War I. Reliable construction cost data are not available for the post-Civil War period; it is, however, possible to secure good data on labor costs.

Figure 5 was prepared to show the relationship between labor and construction costs during the past 35 years,

when excellent records of both are available. This diagram shows the close parallel between labor and construction costs during both rising- and falling-price periods. The use of both labor and construction costs on the same diagram, as in Fig. 4, is therefore reasonably indicative of correct conclusions regarding the effect of wars on construction costs.

It is believed that, in the next depression comparable in its intensity to those of 1932 and 1878 (both of which, incidentally, occurred thirteen years after the termination of hostilities), the *Engineering News-Record* index will not be less than approximately 360, or 25 per cent below the present construction cost levels. It is predicted that general construction costs will never again drop below this level and that this low point will probably not be reached for some years to come. If this assumption is correct, the water works of this continent, in order to maintain the same rate of expansion as in the years between World Wars I and II, must expend approximately \$3.75 per capita annually for new facilities, as compared with the 20-year prewar average of \$1.50. Expansion programs for the next decade should be planned on the basis of construction costs ranging from 75 to 100 per cent above the prewar figures.

In the water works industry, as in others, the worker is worthy of his hire. Utility management must make every effort to secure rates and revenues adequate for its needs. It is the obligation of a water utility to provide sufficient money for its orderly expansion, just as it is to meet operating expenses and create depreciation reserves. As far as possible, these funds should come from current revenues rather than from loans.

Summary

1. Water works must not be forced to curtail development, as is now largely necessary because of inadequate rates and revenues.

2. The war has caused at least a three-year lag in new water works construction at the present time. This deficiency should be overcome.

3. As a general average, water works revenues must be increased about 35 per cent if capital is to be available for new construction.

4. Rate-fixing bodies should take a realistic attitude toward water rates, recognizing that the water works dollar, like all others, has a reduced purchasing power. Rates adequate for present operation and future expansion are to the mutual interest of the utility and those it serves.

5. Users of the cheapest utility service, water, are more interested in good service than in low cost. More than half of all water customers now pay less than 5¢ a day per family. The difference between starvation and fair rates for water utilities is usually less than 2¢ per family ($\frac{1}{2}$¢ per capita) per day.

6. The aftermath of war has made the water industry somewhat anemic. As many water works, both publicly and privately owned, have increased their rates, the industry's condition has improved. A return to full health requires the cooperation of plant management, municipal officials, regulatory bodies, owners and consumers.

Adequate water works revenues today are the best assurance of adequate service tomorrow.

Reference

1. Howson, Louis R. Adjusting Rate Structures to Rising Cost Levels. Jour. A.W.W.A., **39**:819 (Sept. 1947).

Construction Cost Trends in the Southeast

By Lowell Cady

A paper presented on Dec. 6, 1949, at the Southeastern Section Meeting, Albany, Ga., by Lowell Cady, Engr., Wiedeman & Singleton, Atlanta, Ga.

IN examining the trend of water works construction costs, 1936 may be taken as the year which represents the beginning of the real rise. The basic cost information contained in this paper has been obtained from published data and from actual bids on construction during the period 1936–49.

Material Cost Trend

The average 1949 cost of such essential materials as steel, cement, lumber, plumbing and heating items, paint and cast-iron pipe was 2.12 times that of 1936. Lumber prices showed the highest increase, approximately 224 per cent, cast-iron pipe being next with 107 per cent. Cement rose only 48 per cent. The other essential items named showed an average price rise of 75 per cent. The greatest rate of increase has occurred since 1946, with moderate increases from 1936 through 1945. Changes since 1948 are shown in Table 1.

The consensus seems to be that the peak has been reached. Industry is certainly not suffering a great deal from a shortage of materials. According to bankers, merchants and contractors, the seller's market has reverted to a consumer's market. This fact may tend to stabilize and even reduce the price of materials.

Labor Cost Trend

Since 1936 skilled-labor wages have gone up approximately 71 per cent and common-labor wages are up 280 per cent. Both showed a rapid upward spiral from 1945 on. Strikes have been frequent and productivity of labor has lagged far behind in spite of the incentive given by higher wages. This situation has caused construction costs to climb rapidly since 1936, and especially since 1945, when World War II ended. According to the *Engineering News-Record,* labor productivity was rising in 1949. In 1948, based on 100 for 1939, the three major skilled-labor trades (carpenters, bricklayers and ironworkers) had a low-productivity value of 33 and a high value of 90, with 71 as the average. Common labor showed a low of 50, a high of 112 and a mean of 80. These figures are compiled from contractors' reports and are, of course, reflected in production costs.

The most frequent complaint of water works contractors has been that labor quality and production are not what they used to be in 1936–39. Part of this trouble no doubt lies in the rating methods used. Some skilled laborers have been overrated or wrongly classified, and the class of common labor is below that of prewar days.

Miscellaneous Costs

In addition to materials and labor costs, the contractor must consider overhead and contingent expense. The contingent costs are a headache when improvements are made to existing structures and it is necessary to main-

tain a continuous flow of water to the consumer. The need for overtime and work during low-demand periods must be taken into account by the contractor. He must also anticipate possible leaks in existing structures which may be exposed when excavation for the new ones is started. Foundation problems come up as well. Because of these so-called "nuisance factors," the contractor must add a contingent sum to the overall cost. This item cannot be any fixed percentage for all proposed work, but must be estimated for each project after the facts have been studied.

TABLE 1

*Material Cost Changes**

Material	Price (Nov. 1949) $	Change Since 1948 *per cent*
Brick and tiles	25.00/1,000	+2
Cement	2.98/bbl.	+10
Lumber	60.00/1,000 fbm.	−7
Steel†	4.98/100 lb.	−1
Cast-iron pipe	89.50/ton	+6

* Based on *Engineering News-Record* data.
† Average structural shapes and reinforcing steel not fabricated.

Most water works contractors have learned by past experience just how much to allow for contingent costs. The engineer takes note of this feature in preparing the estimate for any improvement. In discussing proposed improvements with contractors, the author has learned that the "nuisance factors" are being considered in more detail today perhaps than in 1936.

During the war years the escalator clause caused a great deal of inconsistent bidding. Since this provision is no longer in effect, better estimates can now be made. The present-day contractor, however, must protect himself with a contingency allowance because of the high cost of labor and materials.

Filter Plant Construction Costs

Actual bid prices on water works improvements will show in brief the trend of filter plant construction costs since 1936. Filter plant improvement costs for small plants (under 3 mgd.) differ greatly from those for larger plants. In 1936 small plants, exclusive of pipelines and pumping stations, cost, on the average, $85,000 per million gallons per day capacity. In 1948 the price had increased to $181,000, or 2.13 times the cost of plants constructed in 1936. For plants of 3–6-mgd. capacity, the cost per million gallons per day capacity averaged $60,000 in 1936 and $134,000 in 1948, or 2.4 times that of 1936. These increases follow closely the overall rise in material and labor costs. Prices for 1949 were lower than for 1948. Actual bids in 1949 for 1–2-mgd. plants were approximately $162,-000 per million gallons.

TABLE 2

Pipe-laying Costs, 1947

Pipe Size *in.*	Cost per Foot—$			
	First Quarter		Last Quarter	
	Low Bid	2nd Bid	Low Bid	2nd Bid
24	3.50	4.90	2.45	2.50
20	3.25	4.55	1.80	2.00
16	3.00	3.10	1.60	1.75
12	2.25	2.40	1.50	1.50
10	2.00	1.70	1.30	1.25
8	1.60	1.70	1.20	1.00
6	1.40	1.40	1.00	1.00

In 1948 bids of $185,000 and $134,-000 (per million gallons) were received for plants of 1-mgd. and 4-mgd. capacity, respectively. The 1948 bids were not accepted and the same plants were relet in 1949. The bids received in 1949 were $144,400 and $114,000

for the 1-mgd. and 4-mgd. plants, respectively. These figures were for plants built at new sites. For improvements to existing plants, the average cost of 1-mgd. or 2-mgd. additions was approximately $188,000 per million gallons in 1948 and $177,000 in 1949.

Pipeline Costs

Complete bids for furnishing and laying pipe are somewhat lacking for 1936 because of government aid to cities. During this period municipalities bought pipe and other material and the laying was done by WPA forces. This situation continued up to 1940 and, therefore, the real cost of pipe laying is not readily obtainable.

The average cost per ton of cast-iron pipe fob. Atlanta area rose from approximately $42 in 1936 to $51 in 1945, but from then on the increase in cost was more rapid. The average price quoted in early November 1949 was approximately $90 a ton, an increase of 112 per cent since 1936; the increase up to 1946 was only 21 per cent.

Many cities are considering and some are using steel pipe with spun bituminous linings and special outside coatings, to keep costs down. In large sizes, 16 in. and up, steel pipe has generally been cheaper when no evaluation of the life of the material is considered. In one instance in 1938, when straight bids were received for 20-in. and 24-in. lines, steel pipe cost approximately 20 per cent less than cast iron.

The laying prices, including joint material, trenching and backfilling, seem to be on the decrease. Table 2 compares two bids received in the first and last quarter of 1947 for laying Class 150 bell-and-spigot cast-iron pipe using lead joints. The conditions of construction, terrain encountered and so forth were nearly alike for the two projects. The trend is definitely downward and follows the pattern of filter plant costs previously mentioned.

Filter Plant Details

Filter plant construction generally involves improvements to existing installations, although occasionally a new site is selected and found to be more economical to use than enlarging the existing facilities would be. This type of construction is ideal from the standpoint of the contractor and the best prices are obtained under these conditions.

Prior to 1936 contractors were not worrying about minor costs arising from items of work that had to be done but were not covered specifically in the contracts. High costs have now forced contractors to develop their cost accounts so minutely that these minor costs are accounted for. This discussion will, however, be confined to the major items of construction, such as foundations, watertight concrete, brickwork, plastering, electrical work, plumbing and heating, and piping.

Needless to say, good foundations are required, especially for the construction of watertight basins. Methods of preparing proper foundations have not changed since 1936, but, using modern equipment, the contractor can perhaps accomplish the necessary excavation with less manpower.

Some contractors previously engaged only in building construction do not realize the importance of obtaining watertight concrete. The method of producing watertight concrete is the same as in 1936, however, and contractors who have been careless in the construction of watertight structures will presumably learn from experience.

Brickwork today is generally inferior compared with 1936. There are a few exceptions to this broad statement, but contractors have often complained about the poor work and slowness of the masons.

Although plastering is still used in filter plants, the results are unsatisfactory. The plaster deteriorates, perhaps because of the excessive moisture encountered. An architect recently stated that gypsum base plaster will always crack but lime base plaster will stay put, although it takes longer to dry. Recently asbestos wallboard and even "Marinite" * insulating material have been used effectively. Tile and painted brick walls are being used as well.

Electrical work today is on par with that done in 1936. Filter plants are really going all out in electrifying the control of equipment, and electronic apparatus is being used advantageously. Consequently, more electrical work details appear on the plans.

The plumbing and heating features of the filter plant have not changed much, except that coal heating seems closer to becoming obsolete because of labor troubles. Coal has always been a messy method of heating, oil or gas being much cleaner and easier to handle. Unit heaters have shown improvement.

The use of steel pipe for filter galleries in large plants is desirable and economical as well. Considerable saving is made in connections, and some economy is afforded because the steel pipe weighs less than the cast iron.

Methods of construction in pipe work have not changed since 1936, but, with labor costs high, the contractor has had to mechanize his construction force.

* A trade name of Johns-Manville Corp., New York.

Conclusions

It is evident that construction costs in the Southeast are extremely high compared with 1936, but apparently they are coming down. Estimates can be made with far more accuracy than has been possible in the last five years. Contractors are quoting bids with lower contingent factors added, and escalator clauses are no longer found. Material is available but still high in price. Labor is gradually approaching prewar efficiency and is not scarce.

Filter plant design and construction are fairly well standardized. Filter rates in excess of 2 gpm. per square foot have already been shown to be possible, a fact which will tend to reduce the high construction costs further, once the public health departments permit such a basic change in design.

The Southeast is experiencing an increase in demand due to population growth, air conditioning and industrial development. Cities are being forced to enlarge their systems and sometimes to extend them considerably outside the municipal limits. Water works facilities will be expanding for some years to come, and long-term programs have been planned and even started by many cities.

Discussion

E. E. Bolls

Engr., Black & Veatch, Kansas City, Mo.

The author has presented a very interesting paper on the subject of construction costs during the past several years. Although the title of the article specifically refers to the Southeast, the writer's experience indicates that construction costs throughout the country have followed the same general pattern. Not only is this true in the water works

industry but also in other utilities, such as sewerage systems, sewage treatment works, electric power generating plants and natural gas systems, as well as in industrial plant construction.

As large a difference in construction costs has been encountered on similar types of projects in adjacent communities as on those in different sections of the country. The increases in cost have been more pronounced in areas where labor unions have extended or increased their activities. This trend may be expected to continue and to spread to communities where union labor is not now a major factor. In such localities, future increases in construction costs can be anticipated.

Many cities in the South which are confronted by the necessity for providing improvements to their water works plant are operating with prewar rates and would like to be able to build at prewar costs. Most people desire to go back to prewar levels on everything except their standard of living and personal income. As long as the majority have this attitude, there is no indication of a return to prewar cost levels except as the result of a national emergency such as a severe depression. Moreover, it might be pointed out that construction costs in 1939 were the highest in history up to that date. Thus, prewar prices look good only in comparison with present-day costs.

Estimates and Actual Costs

Mention has been made that the price peak seems to have been reached and that a downward trend is evident. Although construction costs have come down during recent months, this matter should be analyzed very carefully if it is to be a factor in delaying needed improvements. It is true that more bids are being received at levels considerably below engineers' estimates, but estimates have been raised rapidly during the past few years and the time lag between their preparation and the receipt of bids often creates an erroneous impression of current trends. Most owners and engineers have been plagued during recent years by rapidly rising costs. Owners or responsible officials, at first reluctant to embark on a program that was more costly than they had expected, often became used to the idea of a higher price or else the urgency of the situation forced them to proceed. Sometimes financing was arranged, plans prepared and bids received, only to find that construction costs had advanced far beyond the level previously considered as too high. After several cycles of such embarrassing occurrences, engineers quite properly increased the contingency allowance in their estimates in an effort to anticipate price rises between the time of estimating and the time of receiving bids.

Late in 1948 it became apparent that the rapid rise in construction costs had come to an end. A substantial drop in bid prices was encountered, but estimates were continued at the previous level until the lower construction costs were established on a sufficient number of jobs to indicate the trend. In the latter part of 1948 the highest estimating prices in history were being used. The following figures will perhaps indicate the timing and magnitude of the recent drop in construction costs.

In November and December 1948, the writer's firm awarded similar contracts in Kansas, Oklahoma, Nebraska and Colorado. The total of the successful bids on these projects was $1,901,300. Estimates on these jobs totaled $1,863,800, or 2 per cent below the bid price.

Between January 1 and March 15, 1949, similar contracts were awarded in Kansas, Nebraska and South Carolina,

for a total construction cost of $823,500, compared with an estimate of $990,000, which was 20 per cent above the bid price. By the end of March it was evident that prices were going considerably below the level of late 1948 estimates, and therefore the allowance for contingencies was decreased so that estimating prices were approximately 10 per cent under 1948 estimates.

Between April 27 and November 16, 1949, contracts were awarded, on projects similar to the above groups, in Kentucky, Nebraska, Louisiana, Missouri, Kansas, South Carolina and New Mexico, for a total construction cost of $3,622,900. Estimates based on prices approximately 10 per cent below the 1948 peak indicated a total cost of $4,040,000, which is approximately 10 per cent above the actual bid prices. Thus, it appears that current construction costs are approximately 20 per cent below the peak prices of 1948.

In the writer's opinion, this drop does not represent a trend in the sense that construction costs may be expected to continue in a downward direction. It does signify, however, that the rapidly rising trend has been arrested and that a "vertical" drop in costs has taken place as a number of the indefinite factors or major contingencies in the construction industry disappeared or were clarified. As the author pointed out, these contingencies included escalator clauses, lack of materials, competition for available labor, poor labor efficiency and inability to provide fast repairs on construction machinery. Prior to January 1, 1949, the volume of available work was very large and competition practically nonexistent. Contractors were naturally inclined to bid at prices which would return a larger profit than under the more competitive conditions that now prevail.

The writer believes that the volume of construction will continue at a high level at least until the middle of 1950. At the end of 1949 there was no indication of a further decrease in costs below the then current prices. In fact, there were some indications of slight increases in the future.

Present and Prewar Costs

The reasonableness of present costs is entirely dependent on the basis of comparison. Today's costs appear high when compared with those of 1939, but not when judged against such items as current living costs, property values and bank deposits. The national "metabolism" is much higher than before the war, and, if construction costs reach a correspondingly high level, they should not be considered out of line.

The following data will perhaps be of some value in comparing current and prewar costs. In 1939 a contract was let for the installation of large cast-iron pipe in Kansas. On this job, which included 7,300 ft. of 30-in. pipe across open country, the unit price was $1.12 per foot. Multiplying this figure by 204 per cent, which is the increase shown by the *Engineering News-Record* index, it is indicated that $2.28 per foot would be a reasonable price at present. The actual price for the installation of 9,200 ft. of 30-in. pipe under practically identical conditions in South Carolina in August 1949 was $1.95 per foot.

Other factors that should be considered in comparing construction costs today with those of a number of years ago are "improvement in the arts" and a tendency toward better and more elaborate installations. In a number of plants, savings in operating costs have justified the installation of more labor-saving equipment and control devices. Improvements in treatment facilities

and in the reliability of plant operation brought about by added standby equipment as well as the more rigid requirements of health agencies have generally increased the amount of work involved. Many plants now being constructed would have cost considerably more than those of equivalent nominal capacity which were built a number of years ago, even if there had been no increases in labor, material and equipment costs. In other words, the utility plants, like many families, are faced with much higher living costs, due partly to higher prices and partly to better living standards.

Construction Postponement

The water works industry, just as every other business, must watch all of its expenses, including construction costs, to avoid wasteful operations. But the people are entitled to safe, dependable and adequate service, and, if necessary, rates should be raised to keep the utility in step with the demands of the community. Fortunately, the amount which the vast majority of individuals spend for water is so small that a relatively large percentage increase in the monthly water bill will have less effect on the family finances than the purchase of a few packages of cigarets.

Finally, the writer wishes to emphasize the fact that the effect of any postponement of construction work in anticipation of cost decreases should be carefully analyzed. If further price declines should be realized, it would be logical to assume that interest rates will increase. Most major construction programs undertaken by utilities, whether privately or publicly owned, are financed through relatively long-term bond issues. Consequently, the cost of the improvement includes not only the original construction cost but also the interest on the debt.

For instance, consider a construction job with an original cost of $200,000 at current prices and assume it to be financed over a 20-year period with an interest rate of 2 per cent. The total cost of this project, including interest, would be approximately $240,000. If costs fell so low that this project could be built for $100,000, or 50 per cent below current cost, and if interest rates correspondingly advanced to 4 per cent, the total project cost would be approximately $140,000 and the actual saving would be approximately 41.6 per cent rather than the 50 per cent indicated by a comparison of original costs. If this line of reasoning is carried one step further and an interest rate of 4 per cent is assumed at a time when costs are 10 per cent below the present level, the original cost would then be $180,000 and the interest would be $72,000. Thus, the total project cost would be $252,000, or 6 per cent above the current total. In short, the writer does not feel that a utility which is faced with a definite need for improvements is justified in jeopardizing the service in the hope that construction costs will be materially lower in the near future.

Financing Water and Sewerage Improvements in Kentucky and Tennessee

By W. Howard Hopkin, L. H. Clouser, L. S. Vance and Arthur L. Dow

A panel discussion presented on Oct. 31, 1949, at the Kentucky-Tennessee Section Meeting, Lexington, Ky., by W. Howard Hopkin, Mgr., Jefferson County Sanitation Dist. No. 1, St. Matthews, Ky.; L. H. Clouser, Partner, Wallace & Clouser, Knoxville, Tenn.; L. S. Vance, Tech. Adviser, Metropolitan Sewer Dist., Louisville, Ky.; and Arthur L. Dow, Supt., Board of Public Utilities, Paris, Tenn.

Bond Buyer's Viewpoint—*W. Howard Hopkin*

MOST of the larger cities in Kentucky and Tennessee have complete water and sewer systems. Improvements to water systems will consist chiefly of additions to treatment plants or the development of new supplies.

From the bond buyer's standpoint the problem presented by the larger cities is not primarily one of security but of the price he can afford to pay for the bonds. The number of connections and the operating record in these cities are well established. The question will be whether the net revenues as shown by the past record, with possible savings due to the improvements, will be sufficient to amortize the bonds or whether a rate increase will be necessary. If an increase is needed it will probably not be very substantial, so that the approval of the governing body, and the customers, can be secured without great difficulty. As rate increases for municipally owned systems in Kentucky and Tennessee are not subject to public service commission review, the customers must eventually accept them if adopted by the governing body. Usually the public absorbs such an increase without too much complaint once the need for it has been explained.

Most of the larger communities employ fiscal agents to set up the bond issue—including interest rates, call features, reserve funds and the like; to secure necessary data for various ordinances; and to advertise the issue for sale. The cost of these services is generally more than offset by the savings resulting from the higher sale price of the bonds.

As far as the engineers, public officials and bond buyers are concerned, the smaller communities are the ones which present the most difficult financial problems.

The financing of municipal projects in Kentucky, including water and sewer improvements, is, for all practical purposes, limited to the use of revenue bonds payable solely from the income of the projects. The constitutional provisions on the issuance of general-obligation or tax bonds in Kentucky require approval by two-thirds of the voters at a regular election. The maximum amount of general-obligation

bonds that can be issued varies according to the class of city but is usually far too small to finance any substantial construction project.

In Tennessee, the bond laws are much more liberal, and municipalities can issue bonds with three different types of security: [1] so-called "pure" revenue bonds, secured solely by the income from the project; [2] revenue deficiency bonds, payable primarily from the income of the system but also from a tax levy, if the earnings are inadequate; and [3] general-obligation bonds, payable primarily from taxes but supplemented by the earnings of the system. The latter two types can be approved by the governing body, subject only to a referendum if demanded in a petition by at least 20 per cent of the citizens.

Although the use of special-assessment taxes is allowed in both Kentucky and Tennessee to finance the cost of water and sewer mains, the bond buyers very seldom are interested in this type of security because of unfavorable past experience and because the laws, as a rule, do not allow a sufficient margin between the amount of special-assessment taxes levied and the value of the bonds issued. For instance, if the bond buyers were asked to purchase $100,000 of "pure" special-assessment bonds, they would prefer the issue to be secured by at least $125,000 of special-assessment taxes on a fairly good grade of property, mostly improved. The Kentucky Municipal League is sponsoring a special-assessment bill which incorporates this "cushion."

Bond Buyers' Requirements

Of the 16.6 billion dollars in municipal bonds outstanding at the end of 1947, individuals held 38 per cent; government agencies, 17 per cent; commercial banks, 30 per cent; insurance companies, 8 per cent; and miscellaneous agencies, 7 per cent. These bondholders all want adequate security for the water and sewer issues they buy, but the other requirements vary according to the type of buyer. For instance, when the Reconstruction Finance Corp. or the General Services Administration buys water or sewer issues, security is the main requirement, marketability is a negligible factor and yield is a fixed amount regardless of the reasonableness of security or the condition of the money market at that particular time.

Next to security, individuals want yield and then marketability. Banks generally desire marketability after security, with yield coming third. Insurance companies are always looking for yield and, as a result, the amount of security demanded is not always as great as for banks.

From the bond buyers' standpoint, water and sewer construction may be classified as: [1] extensions and improvements to an existing system; or [2] building of a new system.

If the bond issue is to finance extensions or improvements and the municipality's economic condition is not rapidly declining—as would be true of a coal-mining town where the reserves are limited or a factory town whose industry is moving elsewhere or failing—the bond buyers employ the previous operating records to form a practical estimate of the future increase in earnings at present rates and the probable change in operating expenses which will result from the improvements or extensions. If the estimated coverage is not sufficient, usually for a 25-year period, an increase in rates is requested

before the issue is purchased. The real problem confronting the brokers is the establishment of a coupon rate which will be equitable for the municipality but still attractive to a buyer.

Determining the security of an issue for a new project is much more difficult from the bond buyers' standpoint, particularly since most of the new water and sewer construction will be in the smaller communities, where the question of management, operation and maintenance is a vital one. Attempts to establish security requirements on the basis of past experience are further complicated by the fact that many of the existing systems were constructed with a 45 per cent federal grant at a time when building costs were around 50 per cent of what they are now. In other words, the small community will have to issue approximately four times as many bonds as would have been necessary in 1936 and 1937.

Important Factors

Prospective purchasers of an issue for a new sewer or water project will usually study the following factors: [1] stability and future growth of the community; [2] willingness and ability to pay; [3] past record, if any, of other utility operations; [4] number of assured connections at start of operation; [5] customer increase; [6] debt per connection; [7] reliability of water supply; [8] practicable operating expense; [9] engineer's reputation; [10] assured maintenance and operation supervision; and [11] operating ratio.

Stability and future growth of the community, as well as willingness and ability to pay, must be judged by the bond buyers after talking to representative groups in the community. A study of the past record of other utility operations involves the correct interpretation of figures showing previous results, a task which anyone familiar with utility operations can carry out satisfactorily.

The number of connections assured when a new water system is to start operation is pretty hard to determine. It has been found that signed agreements to take water service are practically worthless without a substantial deposit. If no deposit is required, perhaps as few as 50 per cent of the signers will connect. With only a \$10.00 deposit in effect, many persons will subscribe in order to obtain a water system for fire insurance benefits, but will not connect as long as their present water supply, a well or cistern, holds up. A substantial advance payment on usage, amounting to approximately a year's water rent (\$35–\$50), is usually necessary to hold signers to their agreement.

Future customer growth depends on the extent of connection enforcement, the economic cycle and the availability of service line material. Water connection enforcement is usually difficult. A good rule-of-thumb method for new water connections from existing nonconnected establishments is to estimate 10 per cent annually for the three or four years after the first year's operation. From then on about 5 per cent will connect annually. Of course, this rule will vary considerably according to the type and size of community. Consideration must also be given to the original reason for constructing the new system—the occurrence of an epidemic, failure of private well supplies and so forth.

The number of sewer connections obtainable on a new system can now be figured much more accurately than wa-

ter connections, since most localities are governed by state, county or city health boards which require the elimination of septic tanks if sewer laterals are available. Moreover, the bond buyers usually require the authorizing ordinances to contain a mandatory connection requirement. With proper enforcement by the health authorities, sewer systems should have 100 per cent connection in at least a year after completion of the system.

The maximum allowable bonded debt per connection varies considerably but should be no more than approximately $400 for each individual water service reasonably assured for the first year and $300 for each sewer service assured for the first year. This will make the water and sewer rates for the smaller communities around $3.00 per month for each service, a high figure compared with past experience but not unreasonable when construction costs and lack of government grants are considered.

The reliability of the water supply is another item which is receiving increased attention from bond buyers, particularly when wells are the source. Several well supplies in Kentucky and Tennessee have weakened considerably, with resultant heavy expenditures for obtaining additional water. Most bond buyers now like two wells for a new water project, each yielding enough water to take care of the maximum daily demand with six or seven hours' pumping. Most buyers require that the wells be drilled and tested for quantity and quality before bond money is made available.

In the past one of the errors in determining the net income available for bond retirement has been a low estimate of operating expenses. Most municipal water works will have an operating ratio of at least 40 per cent. It will be higher for larger cities or if the treatment is complicated or rates are under the average. Sewer projects will have an operating ratio of around 30–35 per cent. Formerly a water or sewer superintendent in the smaller communities was assumed to be working on a part-time basis for a salary of $75–$100 a month. This type of operator has proved to be the most expensive labor available. The maintenance of PWA-financed plants has often been discouraging. Meters were not read, leaks were not fixed, pumps and sewer lines were not checked periodically, treatment plants were left to operate themselves. As a result, major repairs are now necessary after fifteen years of operation. Tank painting costs, the relocation of lines due to highway widening, and pump and chlorinating equipment costs were items usually not considered in the engineer's estimates.

After a project had been built many of the bond buyers did not receive regular financial reports or check periodically on the physical condition and efficiency of operation, or on expenditures for extensions and improvements. The larger bond houses and insurance companies are now requiring periodic supervision, by their own or outside personnel, of projects for which they hold bonds. This supervision will gradually be required on almost all revenue bond projects.

The usual coverage required by bond buyers is about 1.3 times the practical estimates of income and expense. For example, if the average annual debt service requirement for a $1,000,000 issue on a 25-year basis is $64,000, the net income, not considering depreciation, should be approximately $83,000.

Because of some unfavorable experiences, bond buyers are looking more closely into the qualifications of the engineer employed by the municipality to design and oversee the construction of the project. On fairly large projects—say, those costing $1,000,000 or more—the trend is to require a nationally recognized engineer to check the design and periodically inspect the work.

In this period of comparatively high construction costs bond buyers often feel that they cannot buy first-lien revenue bonds in sufficient amount to finance the project. Therefore, they are asking that citizens or banks in the community buy second-lien bonds or some of the first-lien bonds of the same maturities as the investors'. Sometimes a general-obligation issue can be floated to bridge the gap. In this way there is engendered considerable local interest which will help to guarantee that the project is run efficiently. Supplemental financing of this type will probably be necessary for some time to come, and the engineer should not overlook this possibility if the prospective buyers will not finance the entire project by first-lien bonds. When the local interests want a project badly enough, they usually find a way to help finance it.

In the past many of the water and sewer bonds were not callable, making it considerably difficult to finance extensions or tie in the weaker sewer issue with the stronger, established water issue. Bond buyers are now more cognizant of the extension problem and the necessity of combining water and sewer issues in order to sell the latter. Most revenue bond issues are now made callable, often at 0.25 per cent a year for the number of years of maturity still remaining, with a maximum call of approximately 103.

Conclusion

The rising demand for municipal sanitation, together with municipal debt and tax limitations, assures an increase in revenue bond financing of municipal water and sewer projects. The engineer should become more conversant with the bond buyers' requirements and problems. Estimates of future connections and maintenance costs should be practical. A defaulted revenue bond is a reflection on the city, the engineer and the bond buyer. Closer cooperation and better understanding of each other's problems will result in sounder revenue bonds with lower interest rates. In turn, a broader market for the bonds will be created, thus making water and sewer projects easier to finance.

Consulting Engineer's Viewpoint—*L. H. Clouser*

The problem of financing water and sewerage improvements cannot be dismissed by the consulting engineer as having no particular bearing on his professional work. The trend toward the use of revenue bonds and away from general-obligation bonds in financing these improvements has more than ever required the engineer to give full attention to this question.

The need for such consideration is particularly true in the smaller cities and towns, and most of the comments offered in this discussion are made with these municipalities in mind rather than the large metropolitan areas. The latter group, with their own experienced, full-time engineering, legal and fiscal staffs, usually have established procedures for financing both large and small im-

provement programs, and accordingly need not depend too greatly on outside assistance and advice in such matters. The consulting engineer, aside from purely technical work, acts primarily in an advisory capacity on financial aspects for clients in this group.

Technical Analysis

Obviously, arrangements for financing a water or sewerage improvement program cannot be made until the cost of the work is established. The first major role of the engineer, then, is to undertake a thorough technical analysis of the problem, including preliminary designs from which costs may be estimated.

In this type of work, facilities are normally designed by the engineer to serve not only the demands of the present, but those of the reasonably forseeable future as well. This objective, in effect, requires an investigation of the existing population and its distribution and trends; zoning regulations and land use; present water works facilities, fluctuations in demand for water, and domestic, commercial and industrial uses; and present sewage works facilities, sewage and industrial waste flows, and physical, chemical and bacteriological characteristics of wastes. From these and other basic data, and from his knowledge and experience in past work, must come the engineer's appraisal of future possibilities, how large a population to serve, how much water to furnish, how much sewage and industrial waste to dispose of.

It is then necessary to examine the adequacy, quality and reliability of potential water supplies, and, for sewerage facilities, the ability of the receiving stream to absorb pollution loads, together with their effects on both local and regional resources and activities.

The experience of the engineer can often readily serve to eliminate potential sources of water supply which do not justify a detailed study and investigation. For those remaining, preliminary designs should be developed for facilities needed to divert or collect the water, to purify or treat it, to transport it to a point of distribution and to distribute it to the individual customer connections. Accompanying these preliminary designs should be the respective preliminary estimates of construction, operation and maintenance cost.

With sewerage facilities, the engineering process is somewhat reversed, in that sewage and industrial waste must first be collected into a system of lateral and trunk sewers which lead eventually to one or more points of treatment or disposal. Since sewers are primarily gravity flow structures, their arrangement is more or less limited by surface topography, with the main trunk sewers following the major watercourses draining the area. Pumping facilities may sometimes have to be used to drain low-lying areas and to divert sewage from a minor watershed to one of major proportions, thereby eliminating the need for a second treatment plant. The possible use of pumping facilities should not be ruled out too quickly; present high construction charges and relatively low power costs permit a considerable number of economic advantages to be gained from pumping which were unavailable not so many years ago.

With the advent of more strict legislative provisions on pollution control and abatement, the treatment of domestic and industrial wastes to some extent is a foregone conclusion, if not yet a

reality. The engineer must determine the degree of treatment necessary and develop the preliminary designs of the various plant facilities needed to meet this requirement. Sometimes a longer trunk sewer, together with a plant furnishing a limited degree of treatment and discharging into a large stream, may require comparison with a short length of sewer and a complete treatment plant discharging into a small stream. Because of plant site limitations, it may also be necessary to compare the economic advantages of two or more treatment processes. As in water works problems, cost estimates of the proposed work should accompany these preliminary designs.

Engineer's Report

These and many other considerations go into the development of a water or sewerage improvement program. A summary of the pertinent data can best be made in report form, accompanied by such preliminary drawings, diagrams and tables as are needed to illustrate the various features of the proposed work. It is pertinent at this point to question the value of including voluminous amounts of detail data in such a preliminary report, as is frequently the practice. More often than not, an excess of information is confusing to the client, although impressive-appearing reports may sometimes result. Better perhaps is the practice of retaining this detail data in the files of the engineer, available for use as required. Comparative construction and operating cost data can be made more readily understandable if construction cost is presented as a fixed annual charge, which, together with the annual operating cost, may be converted to cost per thousand or per million gallons, or some other desired unit of use.

In passing, it may be pointed out that a preliminary report encompassing the detail heretofore mentioned requires not only a lot of office study, but a considerable amount of field investigation and survey work as well. It is a great temptation to many consulting engineers, in trying to meet completion deadlines, to avoid detailed studies and investigations by using general data at hand instead—for instance, to estimate the cost of a filter plant as a unit price per million gallons. This method of estimating may be satisfactory for general discussion purposes or for very preliminary considerations, but it is not conducive to reliable cost estimating. Such items as good contour maps, rock soundings and outline drawings of structures and piping are still necessary to produce reasonably accurate cost estimates.

All of the remarks made up to this point have dealt with the preliminary engineering phases of the improvement program, which are usually sufficient to establish the scope and cost of the project and to determine the amount of the bond issue. The other technical services to be furnished by the engineer involve the preparation of construction drawings and specifications and the supervision of construction. As these services do not relate too directly to overall financing, except to see that the cost of the work is kept within available funds, they are outside the scope of this paper.

Financial Analysis

The best engineered project cannot be carried through to completion unless it can be financed. The introduction of revenue financing in municipal work

has placed the engineer in the position of having to demonstrate, to a certain degree, the financial feasibility and soundness of the proposed work. Very often the ultimate completion of a project depends on the ability of the engineer to justify it economically. Financial data relating to project cost, operating cost, debt service and revenue anticipations should therefore be presented in such an analysis.

It is important to understand exactly what is meant by "project cost." Too often consulting engineers become somewhat ambiguous in their terminology when preparing cost estimates. At times estimated construction costs are added to "engineering and contingencies" and the result called "grand total" or simply "total." The engineer himself knows just what these terms mean and what items of cost are included. To the average public official, however, the terms "total" or "grand total" invariably imply a maximum amount, whether so intended or not. Bond issues have frequently proved to be inadequate in amount because such a "total" has been interpreted as project cost rather than as what it actually is—the sum of the construction and engineering costs. Project cost includes these items, of course, but it should also cover certain incidental expenses, not necessarily confined to engineering, which are applicable to the initiation and subsequent completion of the work. This factor is particularly important to the smaller communities, where surplus funds are not large and are consequently of no benefit in meeting items of project cost not contained in the engineer's estimates. The client should expect, therefore, a clear statement of costs connected with the project, including such items as are noted below.

Construction costs should be presented in some detail and should be expressly confined to labor, material and equipment needed in the actual building or installation of the contemplated facilities. Quantities, unit prices and extended totals should be shown as frequently as possible. Current prices or prices adjusted to the current construction cost index should be used.

For one reason or another, many consulting engineers are reluctant to set forth in a cost estimate a single item for engineering. Such combinations as "engineering and contingencies" and "engineering and administration" are used, but not too often does the single term, "engineering," appear. The overall estimate can be considerably clarified by the use of the single word, and it should include the fee to the consultant for regular services to be performed in the planning, design and construction of the project, together with contingent items for core drilling, special foundation or hydraulic investigations, resident engineers and inspectors, and other miscellaneous services not normally covered by the usual percentage fees.

Costs of land and right-of-ways should be determined by the engineer with the assistance and advice of municipal officials or experts retained especially for such purposes. These costs should include not only the actual value of the land, but such additional items as acquisition cost, property surveys, preparation of legal descriptions and deeds, and a contingent allowance for condemnation proceedings. A determination of these costs is not strictly an engineering problem, and many exceptions—perhaps rightly so—will be taken to burdening the engineer with the responsibility for their inclusion in

a cost estimate, even though such costs are, in fact, a part of project cost.

Administrative and legal expense on a project is usually not an item determined with any initial exactness, and certainly not one requiring any engineering study. The expense is part of project cost, however, and some allowance should be made to cover preparation of ordinances, holding referendums, time and expenses of administrative officials, preparation of special legislative material, advertisements and so forth.

The expense of issuing bonds, likewise not an engineering problem, varies considerably, depending on the size of the issue. The engineer, in consultation with his client and with reputable investment firms, will be able to estimate with reasonable accuracy the costs of obtaining the bond attorney's opinion, the preparation of the bond prospectus, printing, advertisements and the like.

When funds from surplus or from revenue collections are not available, it is customary to include as part of project cost the interest charges coming due during the period necessary for construction. The engineer should be able to estimate construction time with reasonable exactness, and the applicable rate of interest should be applied to this period.

A sustaining fund is often included as an item of project cost to cover part of the operating and interest charges over a limited period after completion of major construction work. Operation is often started before all service connections have been completed, with the result that revenues may not prove sufficient to pay the necessary charges during the first few months. The sustaining fund is used to supplement the revenues until all connections are completed.

A general contingency fund is normally included as a part of project cost. Since the costs of a project must be estimated, they are subject to change because of various factors. Reasonable funds should therefore be provided to meet unforeseen expenses, minor additions in scope or increased costs.

Where systems are being expanded, it is possible to retire existing indebtedness against the system by the issuance of new bonds, provided the existing bonds are callable and a more advantageous interest rate can be obtained. Although not strictly a part of project cost, funds for this purpose are often included therein.

With all of the foregoing items of expense accounted for, the amount of a bond issue necessary for adequately financing the contemplated improvements can readily be determined.

Operating cost is an important item of the engineer's financial analysis of a project, both as a budgetary consideration and for the establishment of rates. Such cost should include an item for part- or full-time superintendence and for a chemist, if the type and size of plant justify the employment of such personnel. Additional items should cover charges for a chief operator and assistants, as required; for both skilled and unskilled casual labor; for chemicals; for fuel and power; and for miscellaneous supplies, such as oil and grease, laboratory materials and meter charts. Charges for system maintenance and repairs may represent a major item of operating cost. For accounting purposes, they are most often kept separate from plant cost.

A third item of the financial analysis is debt service, which, in effect, is the annual payment, made during the life of the bonds, necessary to retire both principal and interest on the full amount

of the issue. The engineer's estimate of this item should be made in consultation with a reputable investment firm. Two general schemes are normally used, one providing for approximately equal annual payments over the life of the bonds, the other for increasing annual payments on a par with increasing annual revenues. Various factors entering into the sale of the bonds will, in all probability, determine the plan finally selected.

Knowing the annual fixed charges and operating costs, there still remains the problem of raising sufficient revenue to meet these annual charges. One of the first steps in undertaking this study is to determine the number and classification of customer accounts. In an existing system, this involves an exploration of present accounts. The annual growth of total accounts during previous years is also essential to estimating future customers. In a new system, a field count of potential customers is necessary, so that the engineer may estimate the various use classifications. A tentative schedule of rates may then be applied to test the revenue-producing ability of the customer accounts. Service charges may also be made for fire hydrant use, meter rentals, sprinkler system connections and the like. The revenue produced from such sources may often be substantial. Any schedule of rates recommended for use should be adequate to provide varying amounts of annual surplus, which, over the life of a revenue bond issue, should furnish a net operating income about 1.5 times the debt service. Although not actually necessary to meet annual charges, most investment firms consider this factor of safety as important in effecting the sale of revenue bonds. The greater this ratio may be, within reason, the more salable the bonds become.

With such an analysis of costs and revenues, the feasibility of financing water and sewerage improvements is readily determinable.

Summary

All of the foregoing discussion has been intended to indicate, in a general way, the type and scope of work that should be undertaken by the engineer, and of the pertinent information necessary to the financing of an improvement program. The engineer's findings, conclusions and recommendations should be presented—preferably in report form—in such a style as to indicate clearly to the client: [1] the advantages and disadvantages of one or more plans of development which are available for use; [2] the plan considered by the engineer to be the most practical and the most economical to develop, when a choice is possible; [3] the extent and type of structures, pipelines, appurtenances and miscellaneous facilities needed in the improvement program; [4] the total estimated cost of initiating and carrying the project through to completion; [5] the estimated annual cost, including fixed charges and operation and maintenance; and [6] the type of rate schedule and service charges needed to insure adequate revenue return.

Municipal Viewpoint—Kentucky—*L. S. Vance*

The first consideration in financing water or sewage works improvements is the ability to justify the need for the project and its selection over some other needed construction, and to substantiate the fact that the construction planned is the best and most economical method for providing the public service

required. In other words, data must be assembled and prepared in order to "sell" the project to a city manager, a town board or commission, a board of aldermen, a board of public works or a board or commission of the water or sewage works, as well as to the general public. Projects of municipal corporations expend public funds and such funds must provide the greatest good for the greatest number.

The next consideration is the determination of the legal authority for the municipal corporation or governmental agency to construct or acquire such water or sewage works or improvements. The Constitution of the United States, the state constitution and the state statutes adopted by the legislature provide such authorization, but they also contain restrictions and limitations, some of which are most unfortunate. An example is Sec. 246 of the Kentucky constitution, which states: "No public officer except the Governor shall receive more than $5,000 per annum as compensation for official services. . . ." The result is that any municipal employee, such as the superintendent of public works or the chief engineer of water or sewerage works or other agencies specifically mentioned in the statutes, is unquestionably a public officer subject to the salary limitation. Compensation for subordinate employees is limited to lesser amounts. Under such conditions there is no incentive for a capable young high-school graduate to continue his technical education in college in anticipation of a career in engineering in any state, municipal or other governmental agency. He can earn more at an earlier date as an artisan, equipment operator, plasterer or bricklayer. Consequently it is impossible to assemble or even maintain adequate and competent design, construction and operating organizations in governmental agencies in Kentucky.

Municipal Organization

The Kentucky constitution (Paragraph 158) authorizes six different classes of cities, ranked by population: first class, over 100,000; second class, over 20,000; third class, over 8,000; fourth class, over 3,000; fifth class, over 1,000; and sixth class, less than 1,000. Paragraph 157 of the constitution limits the general-purposes annual tax rate per $100 of taxable property value to 75¢ in cities of the fourth, fifth and sixth class and in third-class cities with a population less than 10,000. In third-class cities with populations between 10,000 and 15,000, the rate is limited to $1.00 per $100. Third-class cities with populations over 15,000, and second- and first-class cities, are limited to $1.50 per $100. No city can become indebted in any one year beyond the income and revenues provided for that year without the assent of two-thirds of the electorate voting at an election held for the purpose. This proviso means that two-thirds of the voters must approve any general-obligation bond issue of the city. Paragraph 158 further limits the total indebtedness which may be incurred, including existing indebtedness, to the following percentages of the total value of taxable property in the city: first- and second-class cities and third-class cities whose population is more than 15,000, 10 per cent; third-class cities of less than 15,000 and fourth-class cities, 5 per cent; and fifth- and sixth-class cities, 3 per cent. These constitutional limitations have lately caused major changes in municipal financing in Kentucky.

The state legislature has provided by

statute for the organization and governmental authorities of the several classes of cities. The regular organization for cities is a mayor and a legislative body consisting of aldermen, councilmen or trustees. Second-class cities have two boards—aldermen and councilmen. In sixth-class cities, there is no mayor, the trustees being charged with the executive duties. In all cities, the judicial functions are performed by an elected judge.

Cities of the second through the sixth class may adopt a commission form of government, consisting of two to four elected commissioners and, except in fifth- and sixth-class cities, a mayor. The commission combines the legislative and executive functions of government.

Cities of the second, third or fourth class may use the city manager–commission form of government, the manager being appointed by a commission composed as above. On the advice of the city manager, the commission can create or abolish city departments by ordinance. The manager appoints and removes department directors and may remove employees in any department.

The municipal legislative body is the basic authorizing agency at this level of government. The specific statutes and procedures for financing water and sewage works, and the organizations for their construction, control and operation, will be outlined below for the various classes of cities.

First-Class City

In a first-class city, (that is, Louisville) which, through the commissioners of the sinking fund, owns all of the outstanding stock of a chartered water company, the mayor can appoint a four-man board of water works to manage, operate and control the corporation, the mayor himself being an ex officio member. The term of office is four years, one member being appointed each year, thus providing for continuity of policy and subduing the effect of a change in the political complexion of the elected city officers (K.R.S. [Kentucky Revised Statutes] 96.230–96.310).

The board of water works shall provide free water service to the city for municipal uses, and the water works is exempted from the payment of city taxes. The board is authorized to fix and collect reasonable rates for the use of water furnished. All debts of the water works are to be paid out of earnings and income. The board may borrow money not to exceed the gross receipts of the current year and may issue bonds for refunding outstanding bond issues or funding its current floating indebtedness, when approved by resolution of the commissioners of the sinking fund. The limit is $1,500,000, the maximum interest rate is 4 per cent and the bonds must mature within 40 years.

There is no authority for the diversion of water works funds. The Louisville Board of Water Works, however, has for the last nine years declared and paid to the sinking fund commissioners an annual dividend of $1,000,000 to $1,300,000 on the stock of the corporation.

Three methods of building sewers are authorized for first-class cities:

1. Through the department of public works, financed by allocations of the general-purposes ad valorem taxes (K.R.S. 93.020).

2. By a sewerage commission (K.R.S. 93.130–93.270), composed of the director of works and four commissioners

appointed by him for terms of four years each, such appointments to be approved by the mayor and the city legislative body. The construction of sewerage projects is to be financed through the sale of general-obligation bonds, authorized by a vote of the people after passage of an ordinance by the city's legislative body. There is no limit on the amount of bonds which can be voted and issued, except the constitutional restriction on first-class cities that the total of outstanding general-obligation bonds shall not exceed 10 per cent of the total city assessment valuation of taxable property. A sewerage commission does not at present exist in Louisville.

3. Through the present agency, the Louisville Metropolitan Sewer Dist., authorized by K.R.S. 76.010–76.220. These statutes establish a bipartisan board of five members, three appointed by the mayor and two by the county judge. The terms of office are staggered and are four years each. The board is authorized to establish a schedule of rates, rentals and charges to be collected from all real property using the facilities of the district. The revenues and income from such charges are to be used for the operation and maintenance of the sewer system, and it is the duty of the district to rehabilitate, construct, improve and extend the sewer and drainage system as promptly as possible. The board is not authorized to levy ad valorem taxes upon any property whatsoever but is empowered to issue, from time to time, negotiable interest-bearing revenue bonds, secured only by district revenues realized from the collection of sewer service charges. Bonds shall mature within 40 years and the interest rate shall not exceed 5 per cent. An issue of bonds must have the prior approval of the legislative body of the city for any project within the city. Any bonds issued by the district, and income therefrom, are exempt from taxation.

Other Classes

Second-class cities which own a water works may operate it as a department of the city or under a commission of three members appointed by the mayor subject to the approval of the legislative body. The net revenue from the operation of a water works by any second-class city shall be applied to the improvement or reconstruction of the streets and other public ways of the city, to the extension of the water works system or to the payment of interest or principal on water works bonds.

Municipalities of the second through the sixth class may purchase, establish or construct, operate and extend water works. The city legislative body is authorized to issue revenue bonds secured solely from the income of the works, and such bonds will not constitute an indebtedness of the city.

Sewerage and water system projects may be joined for the purpose of original financing. The bonds issued must mature in not to exceed 40 years and the interest rate shall be less than 6 per cent. Additional bonds may be issued for refunding outstanding bonds or for extensions or improvements of the water works. The city legislative body is required to set aside the income and revenue of the water works in a special fund to pay the maintenance, operation and depreciation, as well as in a sinking fund to pay the interest and retirement of the bonds. Adequate rates and charges must be established. Bondholders are protected through provisions for a lien on the properties and the appointment of an operating receiver in the event of default on any

interest or principal payment. The city may be charged for its water use.

Cities of the second through the sixth class are prohibited (K.R.S. 96.540) from selling, leasing or encumbering municipally owned water works without the approval of two-thirds of the legal voters after due notice. This section does not apply to the issuance of revenue bonds.

For sewer construction in second-class cities, K.R.S. 94.020–94.060 authorizes a board of public works (consisting of three members appointed by the mayor) or a mayor-appointed superintendent of public works to have control of all of the operation, construction and reconstruction of sewers, drains, ditches, culverts, canals and streams. Appropriations from the general revenues of the city deemed necessary by its legislative body will be made each year.

The acquisition of sewerage systems may be financed by cities of the second through the sixth class with revenue bond issues. Sewers may be constructed, extended or improved by ordinance in cities other than first class, in cooperation with any federal or state agency. The city's cost is assessed against abutting property on a front-foot basis. Assessments will be a lien against property and may be paid either in cash—when construction is completed or one-half before the start of construction and one-half on completion, as the ordinance may specify—or by the ten-year bond plan. The city legislative body may issue ten-year serial bonds (maturing one-tenth each year) at not to exceed 6 per cent interest. The property holder assessed for the improvement then pays annually, with his tax bill, one-tenth of his total assessment, plus interest on the remaining unpaid portion at the rate per annum which the bonds bear. The bonds are secured by a first lien on property, superior to all other liens except state, county, school and city taxes. No property will be exempt from the assessment.

Second-class cities are authorized to build sewers along or under any public ways of the city, the cost to be paid out of the city general fund or by special assessment of the abutting property. Construction costs may be assessed up to $2.00 per front foot. If the assessment exceeds half the value of the sewer, the excess will be paid out of the city general fund. City property will be assessed and paid out of the general fund. The ten-year bond plan for the payment of assessments is authorized.

Third-class cities are authorized to construct, reconstruct, maintain, alter, repair or change sewers by ordinance, the cost to be paid out of general funds or by special assessment. Benefited property is to be assessed according to superficial area or front footage, on the basis of sewer districts designated by the legislative body. A warrant bearing interest may be issued for the assessment which shall be a lien superior to all others except state, county or general city taxes. The city legislative body may provide that the sewer improvement assessments can be paid on the ten-year bond plan. These improvement bonds are not general-obligation bonds of the city but are secured by a lien on the property assessed. The bonds bear a maximum interest of 6 per cent.

In third-class cities, the legislative body may contract for water service or the city may acquire works of its own. Third-class cities are also authorized to operate their electric and water plants jointly under control of a five-man board appointed by the mayor. All ob-

ligations of the board must be paid solely from revenues and are not obligations of the city. The board may acquire property, operate, maintain and improve the water and electric system, and fix and collect reasonable rates for service, which must be sufficient to pay for operation, interest, bond and sinking-fund requirements, adequate depreciation reserves, taxes or payments in lieu of taxes, and reserves for improvements. Real estate purchases must be in the name of the city for the use and benefit of the board. The city is billed for its use of water or electricity at rates applicable to other customers. Surplus revenues are to be transferred to the sinking fund for the retirement of bonds or for the creation of a cash working fund, the improvement and extension of the system or the reduction of rates. The board is authorized to issue serial revenue bonds, maturing in at most 40 years with interest not to exceed 6 per cent. Bondholders are protected against default on the payment of principal or interest. Holders of 25 per cent of the outstanding bonds may petition the courts for the appointment of a receiver.

Fourth-class cities may assess the cost of sewer construction or improvement up to $2.00 per front foot against the abutting property. If the cost exceeds $2.00 per front foot, the entire cost will be assessed over the whole area of the preestablished sewer district within the city. Sewer construction may include treatment plants. Existing privately constructed sewers may be incorporated into the system, with the city making proper and equitable adjustment. The ten-year bond plan is authorized.

Fourth-class cities which own and operate municipal electric or water plants may issue 4½ per cent interest-bearing warrants due in at most five years, in payment of extensions and improvements. The city legislative body may by ordinance provide how and for what purpose profits, earnings or surplus funds of publicly owned utilities may be used.

In both fifth- and sixth-class cities, construction or reconstruction of sewers and water mains and their connections shall be paid out of the general funds of the city or at the exclusive cost of the abutting property owners only if more than 50 per cent of such owners petition for the improvement, or if four members of the legislative body (out of a total of five or six) vote that the payment be made by the property owners. Fifth-class cities may order that the property owners pay two-thirds of the cost, the city paying the balance. Both fifth- and sixth-class cities may adopt the ten-year bond payment plan for special assessments. In sixth-class cities, repairs must be paid out of general funds.

District Financing

Under Chap. 220, K.R.S., sanitation districts may be formed in counties which contain cities of the first, second or third class. If approved by ordinance, a portion of a first-class city may be included in the sanitation district. The statute provides that all or a portion of any other class of city may be included in the district if approved by a city ordinance. The sanitation district may include areas in more than one county. A board of three commissioners, only two of whom can be members of the same political party, is appointed by the county judge or judges for four years, with staggered terms. The board may authorize the issuance

of 40-year 6 per cent interest-bearing revenue bonds on such terms and conditions as it may determine, for the purpose of acquiring, constructing or extending a sewage system. It may establish rates and charges for sewer service and can enforce their collection in court or by ordering discontinuance of water service to the delinquent premises. Bondholders are protected by a statutory lien on all property of the district.

Chapter 74, K.R.S., provides for the formation of water districts in any county of the state, under conditions similar to sanitation districts, except as to original petitioning for formation. No incorporated city can be included in the district, but the latter may contract to furnish water to any city.

Chapter 58, K.R.S., gives very broad authority to any county, city or governmental agency, instrumentality or other political subdivision (or groups thereof) to acquire, construct, add to, extend or maintain any "public project," such as lands, buildings, structures, works or facilities for public purposes intended for use in the promotion of public health, welfare or conservation of resources. Revenue bonds may be issued to finance construction or extensions. Bondholders are protected against default through an authorization for the appointment of a receiver by a court.

Conclusion

An analysis of the foregoing outline will show some odd or unexplainable discrimination between different classes of cities. Only fifth- and sixth-class cities are authorized to extend water mains on a front-foot assessment basis. Cities of the first class are the only ones not authorized to construct sewers on a front-foot assessment basis. Water works in cities of the first class are not authorized to issue revenue bonds to finance extensions or improvements. The independent and separate board form of organization for the management and operation of water works is authorized only for cities of the first and second class. Third-class cities, if they own both the water and electric plant, can have a separate board. A separate board for the operation and management of sewage works is authorized only for first-class cities.

It is obvious that any municipal corporation faced with the necessity of financing public improvements should retain or employ a competent engineer and a competent legal adviser. If the issuance of bonds is indicated, the advice of experienced and competent underwriters is absolutely indispensable. The prospective bondholders must be adequately protected if the bonds are to be sold at fair and advantageous prices and interest rates.

Municipal Viewpoint—Tennessee—*Arthur L. Dow*

Until recently the most common method of financing water and sewer improvement programs in Tennessee has been through the issue of general-obligation bonds. As Tennessee does not have home rule, most cities are dependent on the whims of the state legislature for laws regulating local bond issues. Within the last few years the issuance of revenue bonds has increased, but many people are not familiar with such debentures and look upon them with some suspicion.

It should be pointed out at the start that a straight sewer revenue bond by itself is not worth the paper on which

it is written, since the municipality or sewerage district has very little power to coerce the customer who refuses to pay his sewer charge. Even if it were possible to prevent the delinquent customer from using his sewer, the local county and state health departments would oppose such action. On the other hand, if the water and sewer revenue bonds are combined into one issue, the municipality has a firm grip on the regulation and collection of water and sewerage fees, as they are billed together. If the customer is negligent or refuses to pay the bill, the municipality can immediately cut off his water supply, and a sewer system is of no value without water. The average citizen will make every effort to pay his water bill.

Expert Services

Any municipality contemplating water or sewer improvements should obtain expert services. It should employ a competent firm of consulting engineers to make a thorough study of the situation and prepare adequate plans and specifications. It is possible to get Federal Works Agency planning loans for this purpose. If the project is built, the loan is paid out of the bond fund, and, if it is not built, the municipality is then under no obligation to repay the loan.

Local officials should work closely with state health department engineers, who are always glad to cooperate with municipalities in studying their needs and are acquainted with consulting firms which will render adequate service. Although state officials will not recommend any particular firm of consulting engineers, they will supply the names of three or four, or perhaps half a dozen, which they know to be qualified. The employment of qualified, experienced consulting engineers will assure a city of a properly designed and efficiently operating plant providing not only for immediate needs but for future expansion as well.

When the time comes to consider the issuance of bonds, it is suggested that the municipality employ a qualified bond house to prepare, advertise and sell them. Such a firm will render this service at a nominal charge and, as the result of experience, is able to correlate the necessary information, write an effective prospectus and take care of all the detail, which the average city is unable to do for itself. The bond house is acquainted with the different laws governing such issues and can save municipalities much trouble and expense, equal to considerably more than the amount of the fee. There are many reputable bond houses in every state, and banks will furnish a list of the ones with which they deal.

Municipal Organization

There are three main types of municipal government in Tennessee: mayor-aldermen, mayor-commissioners and city manager–council. Cities under the mayor-commissioner form are empowered by their charter to issue certain types of bonds without reference to the state legislature for authority. Those under the mayor-aldermen form usually have to refer to the legislature for authority to issue bonds. In municipalities under city manager–council government, the council is empowered to issue bonds without reference to the legislature. Although any municipality operating under a city manager charter has a wide range of authority over bond issues, a petition of protest signed by 5 per cent of the qualified voters (not necessarily property owners) can force a special election to approve or disap-

prove the action of the council in voting for the issuance of certain bonds.

Under Tennessee law, the state health department has the authority to order a municipality to construct suitable sewage disposal facilities. At present, however, there are approximately 50 or 60 cities in the state which would go bankrupt if ordered to build an adequate sewerage system. The health department has been very cooperative and conservative in this matter, and the author knows of no city, with one possible exception, that has been ordered to do so.

Sanitary and Utility Districts

Under the Public Acts of 1901, Chap. 63, small communities of twenty residences within one square mile may set up a small sanitary district for the purpose of sewage treatment and disposal. These districts have the power to elect a mayor, borrow money, set a tax rate (not to exceed 15¢ per $100) and provide for a drainage and sanitary system. The act also provides for a sanitary inspector.

Chapter 248, Public Acts of 1937, permits 25 owners of real property within a proposed district to petition the county court for the incorporation of a utility district to establish a water, sewer or fire protection system. Such a district has no power to levy or collect taxes but can fix, maintain, collect and revise rates and charges for any service to such a level that the system will be self-supporting, and can incur debts, borrow money and issue negotiable bonds with a maximum maturity of 40 years. This act was amended in 1947 (Chap. 76) to give the utility district the power to acquire, construct, improve, extend, consolidate, maintain and operate any of the eight services indicated in the original bill, within or without the boundary of the district. The district may purchase these services from, or sell them to, any municipality, the state, any public institution or the public generally.

Under the Public Acts of 1949, Chap. 23, the utility district is authorized to extend its services beyond its boundaries and to make reasonable charges for their support. These services may not, however, be extended into areas already served by agencies rendering the same kind of service.

Municipal Systems

Municipalities are empowered (Public Acts of 1917, Chap. 129, as amended) to issue and sell bonds for the purpose of construction, purchase and equipment of sewerage, draining and garbage disposal systems or plants. The governing body of the municipality must pass a bond ordinance and call for an election to approve it.

The provisions of Public Acts of 1935, Ex. Ses., Chap. 10, authorize incorporated cities and towns to construct, acquire, improve, extend, operate and maintain public works, undertakings and projects, including sewage treatment and disposal systems; to issue bonds for such construction; to accept federal grants; to contract debts; to assess, levy and collect unlimited ad valorem taxes to redeem bonds and pay interest thereon; to fix, levy and collect fees, rents, tolls or other charges for services rendered; to acquire, by purchase, gift or exercise of the right of eminent domain, and hold and dispose of property. Bond issue procedure requires public notice.

The Revenue Bond Act of 1935 (Public Acts of 1935, Ex. Ses., Chap. 33) authorizes the issuance of revenue bonds by municipalities to construct,

acquire, extend, improve and operate public works—including water, sewerage, and sewage treatment and disposal—inside municipal boundaries and in other jurisdictions with their permission. The project and related bond issue may be authorized by resolution at the same meeting of the municipal governing body by a majority of the members. No provision is made for a general bond election, nor is a certificate of convenience and necessity or a state permit required.

Any municipality is authorized, by Public Acts of 1937, Chap. 184, to refinance, or refinance and improve, any of its enterprises. Money may be borrowed by the issuance of refunding revenue bonds.

Chapter 183, Public Acts of 1945, gives to incorporated cities and towns approximately the same powers as are enumerated in Chap. 10 of the 1935 act. Section 23, however, provides "that the power conferred by this act shall be in addition to and supplemental to, and the limitations issued by this act shall not affect the power conferred by, another law and [is] not in substitution for the powers conferred by any other law. . . ."

Cities and towns are authorized by Public Acts of 1947, Chap. 222, to require owners, tenants or occupants of property within corporate limits to connect with public sanitary sewer faciilties and to cease to use other methods of disposal. This act also provides that water and sewer charges may be combined and permits the discontinuance of either or both services in order to enforce payment.

Summary

There are three generally accepted methods of financing a water or sewer project:

1. General-obligation bonds, issued for the specific purpose of financing water and sewerage construction.
2. General-improvement bonds, a more flexible type of general-obligation bond. Part of the money from a general-improvement bond issue can be used for sewerage and water, part for streets and part for public buildings. Such bonds are usually employed only when each specific improvement requires a relatively small part of the entire funds.
3. Revenue bonds, which, in the author's opinion, are the best type to issue, because the people who are actually served pay for the financing directly. The revenue bond does not constitute a general obligation upon the city but is a mortgage on the revenues which will be derived from the water and sewerage system. Another advantage of revenue bonds is that they can be issued without regard to a city's debt limit.

With the help of competent consulting engineers and qualified bond men, many financial problems can be solved which, at first thought, may have seemed insurmountable. It is surprising how accurately the experts can predict future growth and revenue.

Chlorine Demand Constants of Detroit's Water Supply

By Douglas Feben and Michael J. Taras

A paper presented on Sept. 29, 1949, at the Michigan Section Meeting, Traverse City, Mich., by Douglas Feben, Asst. Supt. of Filtration, and Michael J. Taras, Sr. San. Chemist, both of Dept. of Water Supply, Detroit.

THE Detroit Dept. of Water Supply adopted the practice of free residual chlorination in February 1946. The requirements of this type of treatment are that the chlorine demand of the water shall be completely satisfied and that a free available chlorine residual shall be maintained. In order to meet these requirements, the solution of certain plant control problems was necessary.

The chlorine demand of a water is determined by two factors: [1] the nature and concentration of chlorine-consuming substances present and [2] variable conditions in the chlorination process. According to *Standard Methods* (1): "The chlorine demand of water is the difference between the amount of chlorine applied and the amount of residual chlorine remaining at the end of the contact period. The demand for any given water varies with the amount of chlorine applied, time of contact and temperature." In plant practice, the only variable conditions subject to control are the amount of chlorine applied and the time of contact.

The chlorine demand characteristics of Detroit water have been under investigation since the adoption of free residual chlorination. Both theoretical and practical considerations have been studied. The present report summarizes a study of those conditions which are subject to control in plant practice. By means of a formula which has been developed for calculating the rate of chlorine consumption under variable conditions, preliminary determinations can be employed to predict the amount of applied chlorine necessary for the maintenance of specific residuals in the finished water.

Experimental Procedure

The experimental method used was to take equal portions of raw water and remove the suspended matter from one portion by coagulating it with chemically pure aluminum sulfate and filtering it through laboratory filter paper. Samples so treated were designated "filtered water" to distinguish them from the untreated "raw water." Both raw and filtered samples were brought to the prevailing plant water temperature before being dosed with chlorine. Chlorination was accomplished by measuring from a buret the required amount of carefully standardized chlorine solution, the source of which was the concentrated tray water from within the bell jar of a chlorinating machine. This solution was adjusted to give a concentration of 0.5–0.8 mg. of chlorine per milliliter. The chlorinated samples were bottled in glass-stoppered pyrex flasks, in a manner which excluded any

air from the containers, and were immersed in a bath of running water at the prevailing plant water temperature.

Residual chlorine determinations were made after contact periods of 0.5, 1.0, 2.0, 4.0, 6.0, 8.0, 12.0, 16.0, 20.0 and 24 hours. Only one residual chlorine determination was made from any one flask in a given experiment. This series of experiments measured the effect of time and turbidity on chlorine demand.

Some time-temperature experiments were run similarly, except that the contact time intervals selected were 2, 4, 6

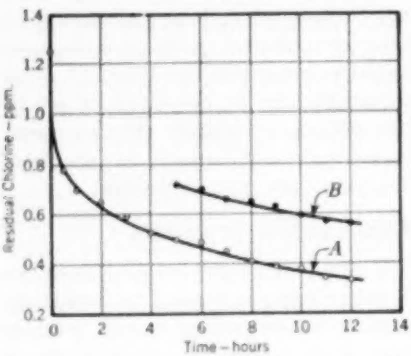


FIG. 1. Effect of Supplementary Chlorine Dose

and 8 hours, and the water bath temperatures were adjusted to 36°, 45°, 55°, 65° and 74°F. The samples of raw and filtered water were both brought to the experimental temperatures before chlorination.

Residual chlorine was measured photometrically by the orthotolidine-arsenite procedure, the instrument being a Cenco-Sheard-Sanford Photelometer.* The 17-mm. tubular cells were used in conjunction with the blue filter. The instrument was calibrated against a series of chlorine concentrations whose titer had been determined by methyl orange titration.

* Made by Central Scientific Co., Chicago.

Mathematical Analysis

The data from a single time experiment are plotted as curve A in Fig. 1. It was found that a straight line resulted when the chlorine demand (dose minus residual) was plotted against time on logarithmic paper (Fig. 2). All the experiments performed in this study

TABLE 1

Chlorine Demand Constants

City or Township	Date of Test (1949)	Water Condition	Temperature F.	Exponential Value
Surface Supplies				
Detroit		filtered	74	0.17*
Flat Rock	Feb. 3	raw†	74	0.16
Flat Rock	July 8	filtered	70	0.17
Utica	July 13	filtered	73	0.16
Well Supplies				
Ann Arbor	Jan. 17		74	0.03
Willow Run	Jan. 28		74	0.06
Ypsilanti Township	Jan. 18		74	0.07
Ypsilanti Township	Jan. 28		74	0.04
Ypsilanti City	Jan. 18		74	0.04
Ypsilanti City	Jan. 28		74	0.06

* Average of 120 values.
† Turbidity trace.

yielded such straight lines when treated in this manner.

The general form of the equation for these curves is:

$$D = kt^n \text{ . . . . Eq. 1}$$

in which D is the chlorine demand (ppm.); t is the contact time (hours); coefficient k is the chlorine demand (ppm.) after one hour of contact and represents the intercept of the curve on the unity time axis; the other constant, the exponent n, is the slope of

the curve and is the tangent of the angle formed by the curve intercepting a horizontal axis. Although the constants for any given experiment can be determined by measurements from a curve which has been drawn to fit the plotted points by inspection, the results so obtained are open to error. All of the data collected in this work were subjected to statistical analysis and the constants determined by the method of least squares. In the example illustrated, the equation becomes:

$$D = 0.54t^{0.21} \ldots\ldots \text{Eq. 2}$$

The effect of adding a supplementary chlorine dose to the raw water, after a given contact period, was also studied, the object being to note the demand attendant upon intermediate chlorination or postchlorination. A raw water was run in duplicate for purposes of this test. The second sample received the same initial dose and then, after a contact period of five hours, was given a supplementary dose of 0.22 ppm. The chlorine demand curve of this second sample is shown as curve *B* in Fig. 1, and it is quite apparent that the two curves are parallel, indicating that the rate of reduction of residual chlorine is independent of the dose.

In all the experiments using raw water, the exponent was found to be in the range 0.12–0.32 with an average value of 0.22. This average value is the result of experiments on 141 samples of raw water involving 1,410 determinations of residual chlorine. In these experiments, the turbidity varied from 1.5 to 82 ppm., and one-hour chlorine demands varied from 0.12 to 1.74 ppm.

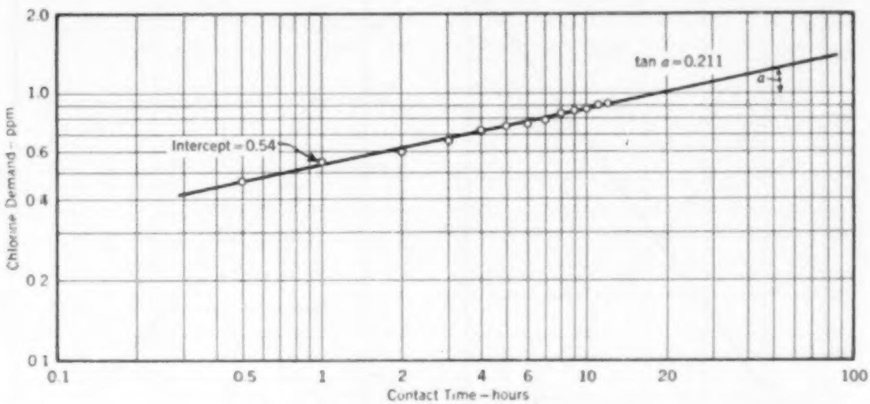


Fig. 2. Raw-Water Chlorine Demand

Turbidity and Temperature

A study of the one-hour chlorine demands of the raw and filtered water showed the one-hour raw-water demand to be higher than the corresponding filtered-water demand in almost all tests. Since the turbidity had been removed from the filtered water, this factor was assumed to be the cause. Accordingly, these differences in demand were plotted against turbidity, as shown in Fig. 3. The difference between the

one-hour demands of the raw and filtered water appears to be a linear function of the turbidity, increasing as the latter rises. Thus, the greater the load of turbidity removed from the raw water before chlorination, the greater will be the difference between the chlorine demands of the raw and filtered water, regardless of contact time.

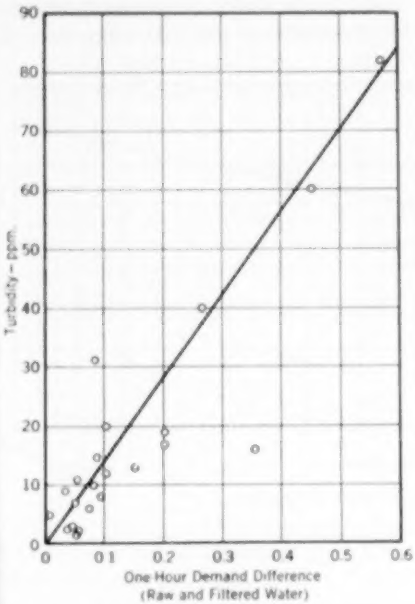


FIG. 3. Effect of Turbidity

From Fig. 4, which shows the exponential differences plotted against turbidity, it is apparent that no relationship exists between the two.

The effect of temperature is apparent when this variable is plotted against the corresponding exponents and one-hour demand values obtained from filtered-water experiments (Fig. 5). These values show a distinct increase with temperature rise.

An anomalous situation prevailed when similar values were plotted for raw water (Fig. 6). The temperature effect is more pronounced on the one-hour demand than on the exponent. Whereas the increase in the one-hour demand is definite and unmistakable, the change in the exponent is of negligible magnitude up to 65°F. A significant increase is not apparent until a temperature of 74°F. is reached.

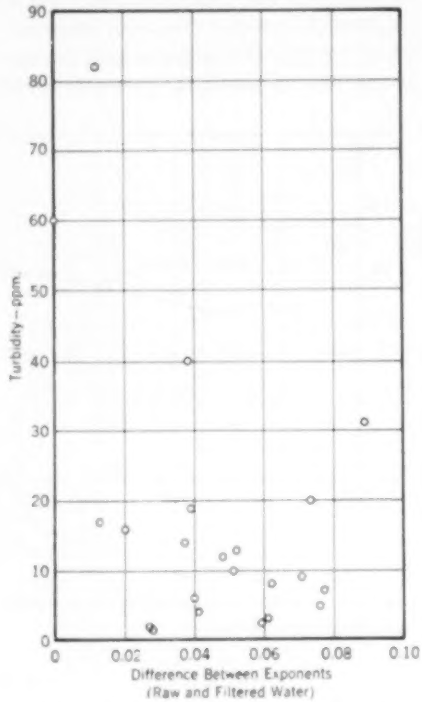


FIG. 4. Turbidity and Exponential Differences

Evaluation of Predictions

The empirical formula developed in this study has been shown to be:

$$D = kt^{0.22} \quad \ldots\ldots \text{Eq. 3}$$

In plant operation, the desired residual

in the plant effluent has been established as 0.50 ppm., and, therefore:

$$Cl_2 \text{ dose} = D + 0.50 \ldots \text{Eq. 4}$$

Equations 3 and 4 have been combined and reduced to the nomographic form shown in Fig. 7, in order to simplify the job of testing the basic formula in plant operation.

At the Water Works Park plant there is approximately a one-hour detention period between the point where prechlorination takes place and the point where the water leaves the mixing chamber. The difference between the residual chlorine in the mixed water and the prechlorination dose was therefore accepted as the *k* value, or the initial demand for any test of the formula. This initial demand was then aligned nomographically with the detention time of either plant to give the total chlorine demand. The formula was tested in this manner against the daily average residual chlorine for the first, fifth, tenth, fifteenth, twentieth and twenty-fifth day of each of the 24 months in 1947 and 1948 at both Detroit plants, comprising a total of 288 checks.

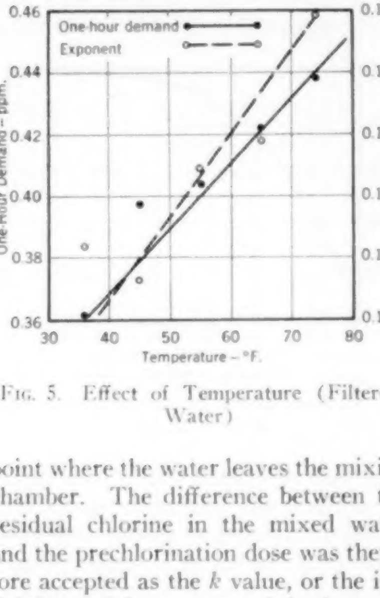


Fig. 5. Effect of Temperature (Filtered Water)

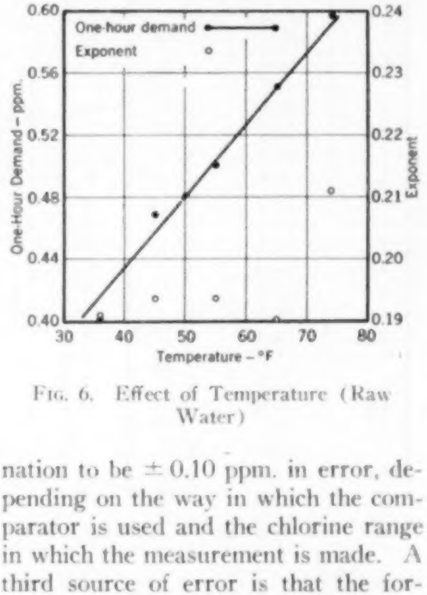


Fig. 6. Effect of Temperature (Raw Water)

It was realized from the start that there were numerous sources of error. In the first place, the mixed-water chlorine residual at Water Works Park seldom results from exactly one hour of contact. Moreover, the comparator used for estimating the mixed-water residuals is not as accurate as a photelometer expertly calibrated and operated, despite the fact that it is good enough for ordinary plant control. It is possible for a visual colorimetric determination to be ± 0.10 ppm. in error, depending on the way in which the comparator is used and the chlorine range in which the measurement is made. A third source of error is that the formula was developed from experiments in which the original concentration of turbidity was in contact with the chlorine at all times, whereas, in plant operation, progressive clarification is taking place. In spite of these possible errors, comparative results were surprisingly good. The percentage of comparisons during this two-year period which agreed within certain percentage

differences is shown graphically in Fig. 8. It will be noted that 74 per cent of the actual and calculated doses agree within 10 per cent, and 81 per cent agree within 12 per cent, or within 1 lb. of chlorine per million gallons, based on a total dose of 1.0 ppm.

During this two-year period the raw-water conditions against which the formula was tested covered a considerable range. Turbidity varied from 2 to 95 ppm., one-hour chlorine demands varied

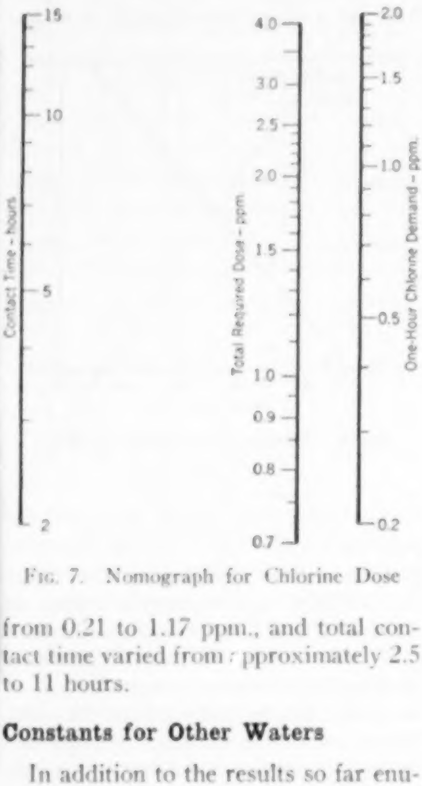


FIG. 7. Nomograph for Chlorine Dose

from 0.21 to 1.17 ppm., and total contact time varied from approximately 2.5 to 11 hours.

Constants for Other Waters

In addition to the results so far enumerated, the chlorine demand constants of several other water supplies have been determined, as shown in Table 1. It is interesting to observe that the ground waters in the Greater Detroit metropolitan area show remarkably similar exponential values, varying between the limits of 0.03 and 0.07. Likewise, the surface waters in this region yield higher but strikingly constant exponents. Samples from which the turbidity was removed by coagulation and sand filtration gave values approximating 0.17 for Detroit, Flat Rock and Utica supplies. Worthy of note in this connection is the fact that Detroit water is drawn from the lower reaches of Lake St. Clair, while the Huron and Clinton Rivers supply Flat Rock and Utica, respectively.

The lower results obtained with well waters suggest that the chlorine demand

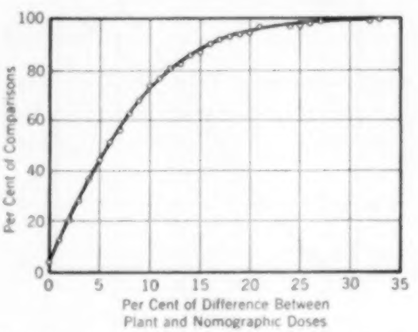


FIG. 8. Comparison of Actual and Nomographic Doses

of ground supplies is due in some measure to inorganic ions and organic materials of relatively simple structure. Conversely, the higher exponents of surface supplies indicate that the demand is attributable to organic materials of greater complexity. This view is not untenable since it is reasonable to assume that water percolating through the earth's strata in the absence of oxygen will result in reduction of some of the nitrogenous matter to ammonium ion. Also, the longer hydrolysis period to which the dissolved solids in the ground waters are doubtless subjected will cause the more complicated pro-

TABLE 2

Comparison of Measured and Calculated Results

Sample Source	0.5-hr. Demand, $D_{0.5}$ *ppm.*	1-hr. Demand, D_1 *ppm.*	Time, t *hr.*	Final Demand, D_t—*ppm.*		Difference	Per Cent Difference
				Measured	Calculated		
Flat Rock	3.42	4.04	7	5.29	6.45	1.16	22
	5.52	5.76	3	5.97	6.16	0.19	3
	2.94	3.40	10	4.90	5.50	0.60	12
	2.94	3.40	24	5.72	6.61	0.89	16
Utica	3.24	3.52	10	5.20	4.63	0.57	11
	3.24	3.52	24	5.80	5.14	0.66	11
Ypsilanti City	2.60	2.76	7	3.08	3.26	0.18	6
Ypsilanti Township	2.61	2.78	7	3.19	3.32	0.13	4
	4.23	4.46	10	4.98	5.33	0.35	7
	4.23	4.46	24	5.20	5.70	0.50	10
Detroit	0.55	0.64	7	0.90	0.98	0.08	9
	0.55	0.64	24	1.16	1.28	0.12	10
	0.47	0.55	10	0.87	0.93	0.06	7
	0.47	0.55	24	1.11	1.13	0.02	2
	0.40	0.44	12	0.65	0.62	0.03	5
	0.40	0.44	24	0.76	0.68	0.08	11
	0.34	0.41	12	0.90	0.80	0.10	11
	0.34	0.41	24	1.12	0.96	0.16	14
	0.37	0.45	12	0.86	0.91	0.05	6
	0.37	0.45	24	1.07	1.10	0.03	3
	0.26	0.29	12	0.57	0.49	0.08	14
	0.26	0.29	24	0.69	0.57	0.12	17
	0.42	0.48	12	0.73	0.77	0.04	5
	0.42	0.48	24	0.84	0.88	0.04	5
	0.30	0.34	12	0.53	0.53	0	0
	0.30	0.34	24	0.62	0.60	0.02	3
	0.72	0.86	12	1.43	1.62	0.19	13
	0.72	0.86	24	1.67	1.93	0.26	16
	0.78	0.95	12	1.71	1.92	0.21	12
	0.78	0.95	24	2.01	2.34	0.33	16

teins to be broken down into materials of simpler structure.

Flexibility of Formula

In some plants, the period between the point of chlorine application and the release of the water from the mixing chamber may be considerably less than one hour. Again, an operator may wish to use laboratory control tests in which the initial demand is to be measured for a contact time of less than one hour. In such instances, the basic Eq. 1 can be transformed and extended to read:

$$C_y = C_0 - \left(\frac{y}{x}\right)^n (C_0 - C_x) \quad \text{..Eq. 5}$$

in which C_0 is the chlorine concentration after zero contact time (chlorine dose); C_x is the chlorine concentration after x hours; and C_y is the chlorine

concentration after y hours, y being greater than x.

It will be seen from Eq. 5 that as x, the contact time for the initial demand determination, C_x, approaches zero, the chlorine residual is being reduced at an ever increasing rate. This means that the degree of accuracy of the contact time measurement must increase inversely with respect to the length of the contact time.

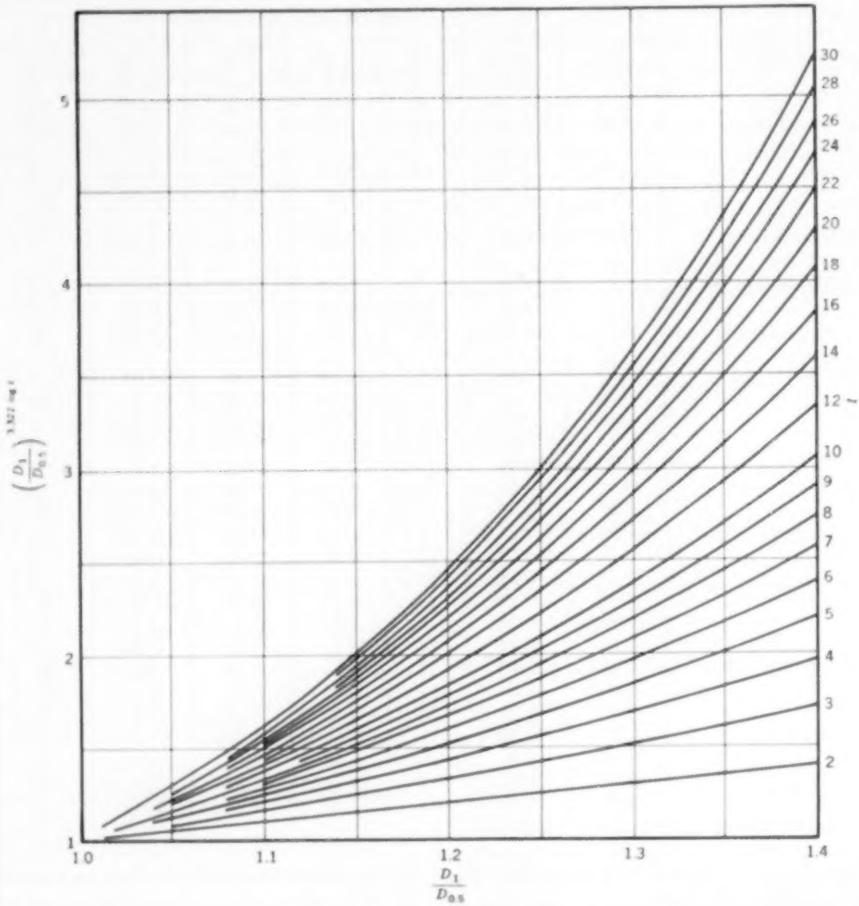


FIG. 9. Graphic Solution of Eq. 6

Equation 5 presupposes a knowledge of the value of n. If this value is not known, or if the characteristics of the raw water are such that n varies over a wide range, the equation can be transformed to read:

$$D_t = D_1 \left(\frac{D_1}{D_{0.5}}\right)^{3.322 \log t} \quad \text{. . Eq. 6}$$

in which $D_{0.5}$ is the demand (ppm.) at

0.5 hour; D_1 is the demand (ppm.) at 1.0 hour; and D_t is the demand (ppm.) at t hours. The use of Eq. 6 requires but two exact determinations of chlorine demand: one at exactly 0.5 hour's contact and the other at exactly 1 hour's contact. From these data, the demand at any other contact period can be calculated.

To test Eq. 6, it was applied to the 0.5- and 1-hour demands of a number of water samples. From the data and results given in Table 2, it will be noted that the average difference between the calculated and measured final demands is 9 per cent. It should be pointed out that the accuracy of the final calculated demand will depend on the accuracy of the measurements of the 0.5- and 1-hour demands. For example, assume a water whose 0.5- and 1-hour demands are 0.46 and 0.54 ppm., respectively. The 10-hour demand calculated from these values is 0.92 ppm. Now assume that the 0.5-hour demand was measured 10 per cent low, that is, 0.41 ppm. Recalculating the 10-hour demand gives a value of 1.35 ppm. against the original figure of 0.92 ppm., equivalent to an error of 47 per cent.

The use of Eq. 6 is simplified by taking advantage of the set of curves given in Fig. 9. The procedure is to divide the 1-hour demand by the 0.5-hour demand and to raise this value to the power determined by the final contact time, t, by means of the appropriate curve. This result is then multiplied by the 1-hour demand, the figure, D_1, and the product is the value sought.

Conclusions

Several conclusions can be derived from these studies:

1. Temperature and turbidity are minor factors in the chlorine demand of Detroit's water supply.

2. When a water is chlorinated to give free chlorine residuals, there is a definite mathematical relationship between the demand at one contact period and that at any other contact period.

3. The mathematical relationship between chlorine demands at different contact periods for Detroit's water supply makes it possible to maintain specific chlorine residuals in the finished water on the basis of preliminary determinations.

4. A study of the chlorine demand constants experimentally derived from various water supplies and from specific compounds offers a qualitative indication of the nature of the chlorine demand substances present in a natural water.

Acknowledgment

The authors wish to acknowledge the assistance and encouragement given them by L. G. Lenhardt, Gen. Mgr., L. V. Garrity, Asst. Gen. Mgr., and W. M. Wallace, Supt. of Filtration, of the Detroit Dept. of Water Supply.

[NOTE: A number of selected plants throughout the country have been invited by the authors to cooperate in an extension of this investigation. They have been requested to collect chlorine demand data using their own supply and a specified procedure; and to submit such data to the authors, who will derive the constants. When completed, a tabulation of the data so gathered will be a valuable contribution to the basic study herein reported.—*Ed.*]

Reference

1. *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).

Preliminary Studies on the Chlorine Demand of Specific Chemical Compounds

By Michael J. Taras

A paper presented on Sept. 29, 1949, at the Michigan Section Meeting, Traverse City, Mich., by Michael J. Taras, Sr. San. Chemist, Dept. of Water Supply, Detroit.

THE chlorine demand characteristics of Detroit water have been under investigation since the adoption of the practice of free residual chlorination. A study reported in the preceding paper (1) reveals that a definite mathematical relationship exists between the chlorine demand for one contact period and that for any other contact period.

When logarithmic values for the chlorine demand are plotted against the logarithmic values of time of contact, the result is a straight line. The slope of this line provides an exponential value which represents the rate of the reaction. This chlorine demand function, although linear for all waters studied, differs in slope and, therefore, in exponential value.

Such a uniform behavior pattern of natural waters prompted further investigation to determine the nature of the chlorine-consuming substances present. This paper presents a summary of laboratory studies of certain inorganic and organic substances which, in solution, exhibit a characteristic chlorine demand.

Chlorine-consuming Substances

Preliminary laboratory studies established the fact that ammonium ion, frequently a contributory factor in chlorine demand, is seldom a constituent of Detroit water. In addition to the ammonium ion, common inorganic chlorine-consuming ions include nitrite, sulfide, ferrous iron and manganous manganese. It is generally considered that the chlorination of these inorganic ions depends upon the oxidizing properties of chlorine. The chlorination of the ammonium ion may be an exception; this reaction is obscure and has not been elucidated satisfactorily with respect to free residual chlorination.

Further laboratory studies revealed that solutions of amino acids and peptones exhibit chlorine demand curves comparable with those characteristic of natural waters. Proteins are a constituent of animal and vegetable life. It is logical, therefore, to suspect the presence of proteins and of their hydrolytic products, peptones and amino acids, in natural waters. Very little of the fundamental chemistry of chlorinating organic substances on the micro scale (parts per million) customary in water treatment processes has been resolved.

Animal and vegetable wastes contain fats, carbohydrates and proteins. Of the three components, proteins alone contain nitrogen and sulfur, the chlorine-consuming elements. Proteins are complex, high-molecular-weight organic materials which have not yet been synthesized in the laboratory. The protein constituents whose chemical struc-

ture has been identified—the amino acids—are less complex, lower-molecular-weight organic materials.

Amino acids are, therefore, an excellent source of the various types of organic chemical groups of protein origin. The highly purified form in which these acids are available makes it possible to determine quantitatively the chlorine demand of representative groups and molecules. A chlorine demand is exerted by the amino group, the sulfhydryl and other sulfur-containing groups, the aromatic as well as the cyclic and heterocyclic rings, and the unsaturated organic linkages which may be present in industrial wastes.

Experimental Procedure

The procedure described in the preceding paper (1) was modified somewhat in the amino acid phase of the work. Experimental temperatures were restricted to the range between 70° and 75°F. The concentration of the active principle, organic and inorganic alike, taken for chlorination was 1.0 ppm.

The free available chlorine residual was measured photometrically by the standard orthotolidine-arsenite method, while the total chlorine was read after the full development of the unarrested orthotolidine color.

All chlorine demand–free water was prepared by heavily chlorinating distilled water to about a 10–20-ppm. residual, using saturated (1.0 mg. chlorine per milliliter) water from under the bell jar of a chlorinating machine. After standing one day, the treated water was dechlorinated by sunlight or by ultraviolet irradiations from a Hanovia Utility Model quartz lamp. An alternative method consisted of boiling the chlorinated water prior to artificial or natural irradiation. No apparent advantage attached to this additional step.

The numerous albuminoid nitrogen analyses performed in this study followed *Standard Methods* procedure (2), the ammonia nitrogen being liberated first by distillation, after the addition of phosphate buffer. The nesslerized color was measured photometrically using a blue filter and a cell with a 5-cm. light path.

The nitrogen analyses were made using 1 liter of ammonia-free distilled water after the addition of 10.0 ml. of the standard amino acid solution. The ammonia distillate from the ammonia nitrogen and albuminoid nitrogen determinations was collected consecutively in separate 200-ml. volumetric flasks, distillation being continued until the volume reached the mark. A 50-ml. aliquot of the distillate was taken for nesslerization. Ammonia nitrogen can be determined at a lower limit of 0.005 mg. per 50-ml. volume by the photometric procedure.

The ferrous iron concentrations of the natural supplies were determined by the *Standard Methods* orthophenanthroline photometric procedure (3). The ferrous analyses varied widely among the well waters and also because the samples were, on some occasions, chlorinated immediately upon receipt in the laboratory. These samples are marked by a high ferrous content. In other tests, it was necessary to postpone the work and analyses for a day or two, thereby allowing the oxidation and precipitation of most of the iron. These samples are characterized by lower ferrous values.

The standard amino acid solutions were prepared by dissolving 0.1000 g. of the pure Eastman Kodak product and diluting with chlorine demand–free distilled water to 1.0 liter in a volu-

metric flask. For each chlorination run, 10.0 ml. of this standard solution plus 10 ml. of 0.4 *N* sodium bicarbonate was diluted with demand-free distilled water up to 1.0 liter or multiples thereof. The peptones and gelatin used were obtained from Difco Laboratories, in Detroit. The inorganic reagents were chemically pure or of analytical-reagent grade quality. The chlorine residual readings used for the mathematical determination of the chlorine demand constants of the various organic and inorganic materials were made after 15 and 30 minutes, then at hourly intervals up to 12 hours and finally after 24 hours' contact time.

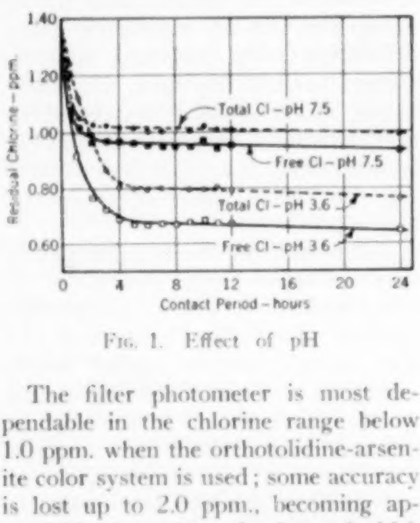


FIG. 1. Effect of pH

The filter photometer is most dependable in the chlorine range below 1.0 ppm. when the orthotolidine-arsenite color system is used; some accuracy is lost up to 2.0 ppm., becoming appreciable above that point, beyond which the color development with respect to concentration is slight. Consequently, working residuals were generally maintained below 2.0 ppm., and sample dilution was employed when the chlorine concentration exceeded this value.

In chlorinating the amino acids, care was taken not to apply starvation doses of chlorine. Chlorine doses were selected to furnish a free available residual of approximately 0.5 ppm. or higher after seven hours' contact. Excessive doses were avoided because of the necessity of diluting the sample to bring the test residuals within the scope of the photometric curves. The object was to simulate as closely as possible the chlorine dosages used in acceptable water works practice.

It was found important to control the pH value of solutions. Ordinary chlorine demand–free distilled water with a pH near 4 yields results differing from those obtained in a natural water. In order to determine the effect of pH on demand, parallel samples of 1.0 ppm. leucine were dosed with 2.25 ppm.

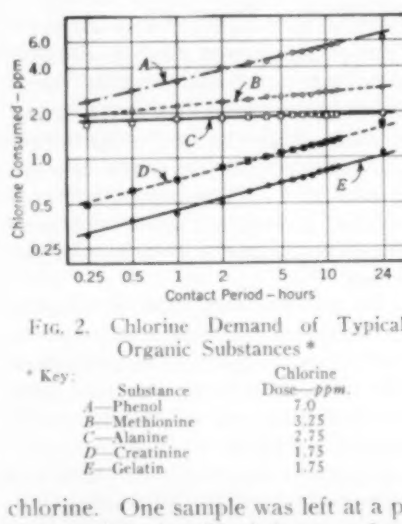


FIG. 2. Chlorine Demand of Typical Organic Substances *

* Key:

Substance	Chlorine Dose—*ppm.*
A—Phenol	7.0
B—Methionine	3.25
C—Alanine	2.75
D—Creatinine	1.75
E—Gelatin	1.75

chlorine. One sample was left at a pH of 3.6, while the pH of the second was raised to 7.5 with sodium bicarbonate. Both readings represented the pH after chlorination. The chlorine demand curves of the two samples (Fig. 1) exhibit the same general trend in that they flatten out after an incipient abrupt decline. The sample with the acid pH, however, shows a higher demand (reflected by the lower free available and total chlorine residuals), greater com-

bined residual formation, a sharper drop in residual and a longer period before the leveling-off process materializes. Because of the mildly alkaline reaction of most natural waters, the picture prevailing at pH 7.5 is probably the more applicable in water purification practice.

The slightly alkaline pH of natural supplies is often due to the presence of bicarbonate ion. Hence, the use of sodium bicarbonate affords the easiest way of duplicating the 7.0–8.3 hydrogen ion concentration typical of most raw waters. Furthermore, the addition of sodium bicarbonate obviates the close control of volume needed with buffer mixtures. Sufficient bicarbonate solution, prepared from chlorine demand–free distilled water, was added to chlorinated solutions to provide a final pH of approximately 7.5, a total alkalinity of approximately 170 ppm.

TABLE 1

*Chlorine Demand Constants * for* $D = kt^n$

Compound	Chlorine Dose Applied *ppm.*	*k* 1-hr. Chlorine Demand *ppm.*	*n* Exponent	Exponent Average
ORGANIC				
Amino Acids				
Alanine	2.75	1.83	0.02	
	2.50	1.78	0.02	0.02
Leucine	2.25	1.25	0.03	
	1.75	1.23	0.04	0.03
Lysine dihydrochloride	2.50	1.41	0.03	
	2.50	1.41	0.03	
	2.25	1.34	0.04	0.03
Glutamic acid	2.50	0.95	0.03	
	2.50	0.94	0.03	0.03
Aspartic acid	2.75	1.79	0.06	
	2.75	1.77	0.07	0.07
Valine	2.25	1.31	0.08	
	2.25	1.29	0.08	
	2.25	1.30	0.08	0.08
Serine	3.00	1.89	0.08	
	2.75	1.82	0.09	
	2.75	1.75	0.10	0.09
Hippuric acid	1.00	0.15	0.01	
	1.25	0.18	0.03	0.02
Cysteine hydrochloride	3.25	2.29	0.06	
	3.00	2.13	0.07	0.07
Cystine	4.25	3.04	0.06	
	4.00	2.95	0.07	
	4.00	2.85	0.08	0.07
Methionine	3.25	2.45	0.08	
	3.25	2.21	0.08	
	3.25	2.28	0.08	
	3.00	2.29	0.08	0.08
Glutathione	2.00	1.17	0.09	
	2.00	1.12	0.09	
	2.00	1.15	0.10	0.09
Arginine hydrochloride	2.75	1.56	0.11	
	2.50	1.49	0.12	
	2.25	1.44	0.12	0.12
Tryptophane	5.00	3.48	0.11	
	5.00	3.26	0.12	0.12
Glycine	4.25	3.31	0.11	
	4.50	3.21	0.12	0.12
Tyrosine	4.75	3.10	0.14	
	4.50	3.07	0.16	0.15†

Compound	Chlorine Dose Applied *ppm.*	*k* 1-hr. Chlorine Demand *ppm.*	*n* Exponent	Exponent Average
Sarcosine hydrochloride	2.50	1.10	0.18	
	2.50	1.12	0.19	0.19
Histidine	2.50	1.05	0.19	
	2.50	1.05	0.21	0.20
Creatine hydrate	1.50	0.55	0.18	
	1.50	0.48	0.20	0.19
Creatinine	1.50	0.66	0.19	
	1.75	0.73	0.21	0.20
Glycine anhydride	3.75	1.67	0.23	
	3.75	1.66	0.25	0.24
Peptones				
Tryptone‡	1.75	0.75	0.12	
	1.25	0.70	0.13	0.13
Neopeptone‡	1.75	0.66	0.16	
	1.25	0.60	0.17	0.17
Manganese peptonate§	1.25	0.48	0.21	
	1.50	0.45	0.21	0.21
Gelatin‡	1.75	0.44	0.27	
	1.75	0.38	0.30	0.29
β-mercaptoethanol	3.75	2.86	0.01	
	3.75	2.84	0.02	0.02
Phenol	7.00	3.26	0.21	
	7.00	3.33	0.21	
	7.00	3.34	0.20	0.21
INORGANIC				
Ammonium nitrogen (added as ammonium chloride)	10.75	9.22	0.00	
	10.75	9.23	0.00	
	10.75	9.28	0.00	0.00
Nitrite nitrogen (added as sodium nitrite)	6.50	5.50	0.00	
	6.50	5.52	0.00	
	6.50	5.55	0.00	
	6.50	5.67	0.00	0.00
Sulfide ion (added as sodium sulfide)	6.00	4.61	0.01	
	6.00	4.65	0.01	
	6.00	4.72	0.02	0.01
Ferrous ion (added as ferrous sulfate)	3.00	1.53	0.02	
	3.00	1.55	0.02	
	3.00	1.56	0.02	0.02

* Obtained by chlorinating 1.0 ppm. of each compound, ion or substance. For explanation of equation, *see* footnote, p. 466.

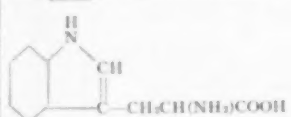
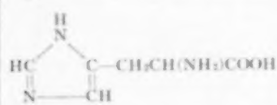
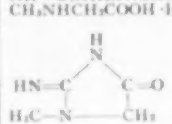
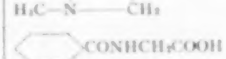
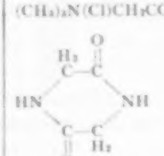
† Applicable over 1–24-hour period.

‡ Difco.

§ Merck.

TABLE 2

Relationship Between Albuminoid Nitrogen and Total Nitrogen in 1.0 ppm. of Various Amino Acids

Compound	Formula	Total N (Calcd.) *ppm.*	Total No. of N Atoms in Molecule	Albuminoid N (Exptl.) *ppm.*	Nearest Whole No. of N Atoms (Exptl.)
Glycine	NH_2CH_2COOH	0.19	1	0.17, 0.16, 0.16	1
Alanine	$NH_2(CH_2)_2COOH$	0.16	1	0.16, 0.15, 0.15	1
Valine	$(CH_3)_2CHCH(NH_2)COOH$	0.12	1	0.10, 0.10, 0.09	1
Leucine	$(CH_3)_2CHCH_2CH(NH_2)COOH$	0.11	1	0.09, 0.08, 0.08	1
Lysine dihydrochloride	$NH_2(CH_2)_4CH(NH_2)COOH \cdot 2HCl$	0.13	2	0.10, 0.10, 0.10	2
Aspartic Acid	$HOOCCH_2CH(NH_2)COOH$	0.11	1	0.08, 0.08, 0.08	1
Glutamic Acid	$HOOC(CH_2)_2CH(NH_2)COOH$	0.08	1	0.07, 0.07, 0.07	1
Serine	$HOCH_2CH(NH_2)COOH$	0.13	1	0.11, 0.11, 0.11	1
Methionine	$CH_3S(CH_2)_2CH(NH_2)COOH$	0.09	1	0.08, 0.08, 0.07	1
Cysteine hydrochloride	$HSCH_2CH(NH_2)COOH \cdot HCl$	0.09	1	0.08, 0.07, 0.07	1
Glutathione	$HOOC(CH_2)_2CH(NH_2)CONHCH(CH_2SH)$-$CONHCH_2COOH$	0.14	3	0.06, 0.06, 0.06	1
Tyrosine		0.08	1	0.08, 0.07, 0.07	1
Tryptophane		0.14	2	0.10, 0.09, 0.09	1+
Histidine		0.20	3	0.10, 0.11, 0.12	2
Cystine	$HOOCCH(NH_2)CH_2SSCH_2CH(NH_2)COOH$	0.12	2	0.08, 0.07, 0.07	1
Arginine hydrochloride	$NH{=}C(NH_2)NH(CH_2)_3CH(NH_2)$-$COOH \cdot HCl$	0.27	4	0.10, 0.09, 0.09	1+
Creatine hydrate	$NH{=}C(NH_2)N(CH_3)CH_2COOH \cdot H_2O$	0.28	3	0.04, 0.03, 0.03	−1
Sarcosine hydrochloride	$CH_3NHCH_2COOH \cdot HCl$	0.11	1	0.08, 0.07, 0.07	−1
Creatinine		0.37	3	0.06, 0.05, 0.05	−1
Hippuric Acid		0.08	1	0.01, 0.01, 0.00	0
Betaine hydrochloride	$(CH_3)_3N(Cl)CH_2COOH$	0.09	1	0.00, 0.00, 0.00	0
Glycine Anhydride		0.25	2	0.13, 0.13, 0.12	1

(as $CaCO_3$) and a total-solids content of approximately 230 ppm.

Chlorine Demand Constants

The chlorine demand curves of most of the chemical substances investigated in this project were of an exponential character and obeyed the general expression offered in Eq. 1 * of the pre-

* $D = kt^n$, D being the chlorine demand (ppm.); k, the chlorine demand, (ppm.) after one hour of contact; and t, the contact time (hours).

ceding paper (1), differing only in the value of the exponent, *n*, and the first-hour demand, *k*. The logarithmic curves for the chlorine demands of 1 ppm. of five typical organic substances are presented in Fig. 2.

The exponent reveals the speed with which the chlorine reacts with a given substance. As might be expected, the rate of reaction is more rapid for inorganic ions (including ammonium ion), with the exponent approaching a minimum. Organic materials, on the other hand, react at a slower rate, and, consequently, the exponent is larger.

The list of amino acids in Table 1 shows a definite pattern. With two exceptions, the simpler acids are grouped at the numerically lower end of the exponential scale, while the more complicated or substituted compounds occupy the other extreme of the scale. The simpler acids are compounds possessing fully hydrogenated amino groups, freely available for chlorination.

Examination of the albuminoid nitrogen analyses of all the amino acids in Table 2 shows that, with but a few exceptions, the analyses of the straight-chain compounds approach the theoretical values for whole amino groups. Considering the experimental error possible in such multiple micro determinations, agreement between the theoretical and laboratory data is good. The conjecture is also valid that the slightly low experimental results may be inherent in the procedures adopted. Whatever its minor quantitative shortcomings, the albuminoid nitrogen determination serves as a satisfactory index of the magnitude of the amino nitrogen groups which can be chlorinated immediately.

In preparing Table 3, the theoretical nitrogen content representing a whole amino group was taken as the most probable nitrogen value for computing the theoretical chlorine demand. This procedure was followed where the experimental albuminoid nitrogen analyses reasonably approximated a whole number of nitrogen atoms (Table 2). The precaution eliminated the possibility of compounding experimental errors in the calculations. The theoretical nitrogen value was multiplied by ten to give the calculated chlorine demand due to nitrogen.

Investigations (4, 5) have established that between nine and ten times as much chlorine by weight reacts with ammonia nitrogen during the free residual chlorination process. Confirming these reports, a similar 10:1 chlorine-nitrogen ratio was observed in the immediate chlorination of the available nitrogen in amino acids. Ten times as much chlorine by weight represents four atoms of chlorine for each susceptible nitrogen atom.

When the analyses differed substantially from the calculated values for whole amino groups, as for creatine hydrate, creatinine and others, the agreement between the laboratory data (chlorine demand and albuminoid nitrogen content) was better than the values based on theoretical considerations. In the absence of information on chemical structure, as for the various peptones and gelatin, the agreement between the chlorine demand calculated from the albuminoid nitrogen analysis and the fifteen-minute flash demand was also good.

The data indicate that all nitrogen groups cannot be chlorinated with equal ease.

Natural Waters

To reduce the results obtained in these fundamental studies to a practical water plant level, ground and surface

TABLE 3

Relationship Between Fifteen-Minute Free-Chlorine Demand and Albuminoid Nitrogen

Compound	Most Probable Albuminoid N Content	Calculated 15-min. Cl Demand			Cl Dose Applied	Exptl. 15-min. Free-Cl Demand	Exptl. Avg. Demand	Difference Between Calcd. and Exptl. Demands
		Due to N	Due to S	Total				
	ppm.							
Alanine	0.157	1.57		1.57	2.50	1.66		
					2.50	1.62		
					2.75	1.70	1.66	+0.09
Valine	0.120	1.20		1.20	2.25	1.03		
					2.25	1.07		
					2.25	1.08	1.06	−0.14
Leucine	0.107	1.07		1.07	1.75	1.07		
					2.25	1.07		
					2.25	1.09	1.08	+0.01
Lysine dihydrochloride	0.128	1.28		1.28	2.25	1.23		
					2.25	1.28		
					2.50	1.41	1.31	+0.03
Aspartic Acid	0.105	1.05		1.05	2.25	1.30		
					2.75	1.35		
					2.75	1.37	1.34	+0.29
Glutamic Acid	0.076	0.76		0.76	1.75	0.77		
					2.25	0.85		
					2.50	0.93	0.85	+0.09
Serine	0.132	1.32		1.32	2.25	1.36		
					2.75	1.38		
					2.75	1.49		
					3.00	1.28	1.38	+0.06
Methionine	0.094	0.94	0.95	1.89	2.50	1.92		
					3.00	2.07		
					3.25	1.90		
					3.25	1.97	1.97	+0.09
Cysteine hydrochloride	0.088	0.88	0.90	1.78	3.00	1.89		
					3.00	1.90		
					3.00	1.95	1.91	+0.14
Glutathione	0.046	0.46	0.46	0.92	2.00	1.00		
					2.00	1.01		
					2.00	1.02	1.01	+0.09
Arginine hydrochloride	0.134	1.34		1.34	2.25	1.23		
					2.75	1.12		
					2.75	1.13		
					2.75	1.32	1.20	−0.14
Creatine hydrate	0.033*	0.33		0.33	1.50	0.20		
					1.50	0.32		
					1.50	0.33		
					1.75	0.36	0.30	−0.03
Sarcosine hydrochloride	0.073*	0.73		0.73	2.50	0.76		
					2.50	0.85		
					2.50	0.87	0.83	+0.10
Creatinine	0.053*	0.53		0.53	1.50	0.49		
					1.75	0.51		
					1.75	0.55	0.52	−0.01

* Average of experimental values.

TABLE 3 (*contd.*)

Compound	Most Probable Albuminoid N Content	Calculated 15-min. Cl Demand			Cl Dose Applied	Exptl. 15-min. Free-Cl Demand	Exptl. Avg. Demand	Difference Between Calcd. and Exptl. Demands
		Due to N	Due to S	Total				
	ppm.							
Hippuric acid	0.007*	0.07		0.07	1.25	0.13		
					1.25	0.28		
					1.00	0.10		
					1.00	0.14	0.16	+0.09
Glycine anhydride	0.123	1.23		1.23	3.00	1.37		
					3.50	1.32		
					3.75	1.27	1.32	+0.09
Betaine hydrochloride	0.00*	0.00		0.00	1.00	0.05		
					1.00	0.10		
					1.00	0.17	0.11	+0.11
Neopeptone	0.04*	0.40		0.40	1.25	0.49		
					1.75	0.54		
					1.75	0.54	0.52	+0.12
Tryptone	0.05*	0.50		0.50	1.25	0.59		
					1.75	0.64		
					1.75	0.66	0.63	+0.13
Manganese peptonate	0.04*	0.40		0.40	1.25	0.39		
					1.50	0.35		
					1.50	0.41	0.38	−0.02
Gelatin	0.03*	0.30		0.30	1.75	0.25		
					1.75	0.31		
					1.75	0.34	0.30	0
Glycine	0.187	1.87		1.87	4.25	2.81		
					4.50	2.62		
					4.75	2.75	2.73	+0.86
Cystine	0.077*	0.77	1.48	2.25	3.25	2.49		
					4.00	2.65		
					4.25	2.55	2.56	+0.31
Tyrosine	0.084	0.84		0.84	4.75	1.53		
					4.75	1.60		
					4.75	1.70	1.61	+0.77
Tryptophane	0.070	0.70		0.70	5.00	2.74		
					5.00	2.80		
					5.00	2.80		
					5.00	3.04	2.85	+2.15
Histidine	0.134	1.34		1.34	1.50	0.87		
					2.50	0.78		
					2.50	0.80		
					2.50	0.80		
					2.50	0.90	0.83	−0.51
β-mercaptoethanol			2.72	2.72	3.75	2.80		
					3.75	2.80		
					3.75	2.73	2.74	+0.02

* Average of experimental values.

water samples were collected in the Greater Detroit metropolitan area. These samples were analyzed for the most common chlorine-consuming agents, and the demand was computed from the amounts of ammonia, albumi-

TABLE 4

Comparison Between Calculated and Experimental Fifteen-Minute Free-Chlorine Demands of Natural Supplies

Source of Supply	Date (1949)	Chemical Analyses				Calculated Chlorine Demand			Exptl. 15-min. Free-Chlorine Demand	Chlorine Dose Applied
		Ammonia Nitrogen	Albuminoid Nitrogen	Ferrous Ion	pH of Water	Due to Nitrogen*	Due to Ferrous Ion†	Total		
		ppm.								
Detroit (raw)	Jan. 24	0.00	0.05	0.00	7.7	0.50	0.00	0.50	0.57	1.02
	Feb. 1	0.00	0.04	0.00	7.8	0.40	0.00	0.40	0.46	0.86
	Mar. 10	0.00	0.04	0.00	8.1	0.40	0.00	0.40	0.30	0.75
	Mar. 29	0.00	0.04	0.00	7.5	0.40	0.00	0.40	0.41	1.25
	Apr. 1	0.00	0.05	0.00	7.9	0.50	0.00	0.50	0.55	1.03
	May 2	0.00	0.04	0.00	8.1	0.40	0.00	0.40	0.45	0.90
	June 20	0.00	0.05	0.00	8.2	0.50	0.00	0.50	0.56	1.01
Ann Arbor (well)	Jan. 18	0.09	0.04	0.15		1.30	0.10	1.40	1.52	2.25
	Aug. 3	0.00	0.02	0.03	7.8	0.20	0.02	0.22	0.35	2.00
Ypsilanti Township (well)	July 29	0.24	0.12	0.36	7.8	3.60	0.23	3.83	4.10	5.25
Frazer Village (well)	Aug. 9	0.11	0.09	0.10	8.1	2.00	0.06	2.06	2.19	4.75
Clawson Village (well)	Aug. 10	0.16	0.05	0.05	8.1	2.10	0.03	2.13	2.44	3.50
Flat Rock (filtered raw)	July 8	0.00	0.12	0.00	7.4	1.20	0.00	1.20	2.60	7.00
Utica (filtered raw)	July 13	0.02	0.13	0.00	7.5	1.50	0.00	1.50	2.85	7.50

* ppm. Cl_2 = **10** (ppm. ammonia N + ppm. albuminoid N).
† ppm. Cl_2 = **0.64** (ppm. ferrous ion).

noid nitrogen and ferrous iron, the three substances present in determinable concentrations. Then the calculated chlorine consumption was compared with the experimental fifteen-minute free-chlorine demand. The results are reported in Table 4.

The agreement between the actual and the calculated demand is well within experimental error for the ground waters tested. For example, the difference between the calculated and experimental values in two Ann Arbor samples is 0.12 and 0.13 ppm., respectively; the difference is 0.13 ppm. for Frazer Village, 0.27 for Ypsilanti Township and 0.31 for Clawson Village. The computed demands for Ypsilanti Township and Clawson Village represent 93 and 87 per cent, respectively, of the actual immediate demands.

The same picture is offered by the Detroit surface supply, which is, as a rule, relatively light in organic pollution. In this instance, however, the fifteen-minute chlorine demand appears to be a direct function of the albuminoid nitrogen content, since other demand constituents are either absent or occur in insignificant traces. The chlorine applied to the Detroit raw water samples equaled the prechlorination dosage fed to the plant raw water on the given day.

On the other hand, highly polluted surface supplies, like those treated at Flat Rock and Utica, yield higher experimental fifteen-minute demands than predicted by the chemical analyses. The complex composition of these raw supplies, containing organic color and other substances for which no analysis is currently available, probably accounts for the deviation. Organic sulfur may well be one of these unknown agents, and industrial wastes are another possible factor in the discrepancy. In any event, these supplies represent the work still involved in the problem of chlorine demand substances. The extent of the problem is demonstrated by the fact that almost half of the demand of these two supplies cannot be accounted for on the basis of present knowledge.

Summary and Conclusions

These studies reveal the importance of the molecular architecture of the individual chemical compound in determining the magnitude of the chlorine demand. Inorganic ions, such as ammonium, nitrite and sulfide, combine rapidly with chlorine, completing the reaction in a comparatively brief time. Conversely, organic compounds generally require longer reaction periods.

The fifteen-minute chlorine demand of most amino acids and such organic materials as peptones and gelatin is related to the amount of albuminoid nitrogen. The albuminoid nitrogen determination measures the amino nitrogen freely available for immediate chlorination. The term "free available nitrogen" is admissible in connection with the fifteen-minute free-chlorine demand.

The exponential chlorination curves of many amino acids and peptones are similar to those obtained with natural water supplies. The course of chlorination, as indicated by the exponential reaction constant, is dependent on the structure of the individual amino acid. An increase in structural complexity, either through substitution or the introduction of aromatic and heterocyclic rings, results in higher reaction constants and prolonged chlorine demand. Gelatin, the only protein investigated in this work, yielded the highest exponential value or velocity constant.

Data collected on Detroit raw water and some neighboring ground water

supplies relatively light in organic pollution bear out the albuminoid-nitrogen and fifteen-minute chlorine demand relationship. The experimental demands of highly polluted natural waters fell far short of the computed values.

These investigations emphasize the complexity of the chlorination problem and the need for additional analytical procedures and tools to study highly polluted supplies. The amino acids provide a good cross section of the organic chemical groups but do not exhaust the possibilities in this direction, particularly in view of the prodigious molecular weight of the proteins.

Acknowledgment

The author wishes to express his appreciation for the encouragement and counsel offered in the conduct of this research by L. G. Lenhardt, Gen. Mgr.; L. V. Garrity, Asst. Gen. Mgr.; W. M. Wallace, Supt. of Filtration and Sewage Treatment; and Douglas Feben, Asst. Supt. of Filtration, all of the Detroit Dept. of Water Supply. In addition, the author gratefully acknowledges the assistance of the following technical associates, who performed many of the reported analyses: H. D. Cisco, J. J. Gazvoda, A. M. Hill, Martin Horowitz and D. B. Kahn.

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Discussion—Chlorine Demand Constants

L. L. Hedgepeth & H. A. Faber

Respectively, Tech. Consultant, Calco Chem. Div., American Cyanamid Co., Bound Brook, N.J., and Research Chemist, The Chlorine Institute, Inc., New York.

The papers by Feben and Taras report the discovery and application of new information concerning the behavior of chlorine in water. The authors have "experimented successfully" in accordance with the definition by Velz (1): "The essence of the scientific method is experimentation. Successful experimentation depends upon careful collection and classification of facts, the discovery and examination of mutual relationships of groups of facts, and the understanding of the significance of the relationships."

The chlorine demand constants of Detroit's water supply were determined, first, by the careful collection and classification of facts; and, second, by the discovery and examination of mutual relationships of groups of facts. The preliminary studies on the chlorine demand of specific chemical compounds contribute to an understanding of the relationships between these compounds and the chlorine demand of natural waters.

Fundamental knowledge of the chemistry of water chlorination has long been

needed, and investigations of this nature are few indeed. It was little more than twenty years ago that Howard and Thompson (2) studied the chlorine demand of taste-producing substances in water and Scott (3) recognized the specific chlorine demand of phenols. Shortly thereafter Gerstein (4) recorded breakpoint data following the addition of successive increments of chlorine to water. Interest in such studies was renewed ten years ago by the investigations of Calvert (5), Faber (6) and Griffin (7), and has been extended by the detailed studies reported by Chamberlin and Glass (8), Fair (9) and many others. Out of this work has developed the present differentiation between "free" and "combined" available chlorine residuals. Hallinan (10) was the first to provide a method for measuring these two types of residuals.

Limitations

Feben and Taras have now added an element of precision in predicting the behavior of chlorine residuals in natural waters. Through the application of this contribution, water chlorination will become more of a science and less of an art. The authors' statistical conclusions and mathematical relationships appear correct and in order. In their joint paper, the authors have well demonstrated the validity of their formula. The extent of its application at other water treatment plants, however, will be determined by two major limitations:

1. *Both technical staff and facilities on the level required for accurate determination of the chlorine demand constant of the water must be available at the plant.* Not many plants are blessed with the personnel and financial resources which were utilized in the present investigations. Unfortunately, in the majority of plants, limited laboratory facilities and the multiplicity of duties of the operator-chemist make a high degree of control impracticable.

2. *The chlorine-consuming pollutants in the raw water must be relatively constant in composition and concentration.* Otherwise, the method of control cannot be readily applied. The authors have recognized the limitations imposed by this requirement, pointing out that further studies are required for heavily polluted waters.

The application of the mathematical relationship involved in the chemistry of chlorine-consuming substances deserves further comment:

1. Water purification differs from most chemical process industries in that the water plant has little control over its principal raw material, the water. Variations are the rule rather than the exception. For this reason, it may be difficult to translate laboratory studies on pure compounds into practice when the water plant deals with natural or man-made pollution.

2. The chlorine requirements of sulfur pollutants vary, and care should be taken to distinguish between the chlorination of low-level sulfide solutions, such as septic sewage, and high-level sulfide solutions, such as those containing organic sulfur. The chlorination of the former solutions results in the precipitation of colloidal sulfur, and a weight ratio of 2.2 parts of chlorine is found for each part of sulfur. When a high sulfur concentration or organic sulfur is present in the solution, the sulfur may emerge from the reaction as either the sulfate or sulfur chloride. With the latter condition, high chlorine-sulfur ratios are valid.

3. The nitrogen compounds exhibit wide differences in their reactions with chlorine. The relation between albumi-

noid nitrogen and fifteen-minute chlorine demand is striking and significant. The use of the term "free available nitrogen" does not appear advisable until the characteristics of many more nitrogen compounds have been determined; several important amino acids have already been found not to conform to their predicted behavior. Further studies are required before the albuminoid nitrogen content of water can be employed as a reliable index of chlorine requirements.

4. There is a definite difference between the oxidation of nitrogenous compounds with hot, concentrated and highly alkaline permanganate solutions, as compared with their oxidation with cold, dilute and acid solutions of chlorine. These experimental conditions make it difficult to discover a theoretical or experimental relationship.

Future Applicability

As a practice becomes more complex, there is a tendency to eliminate personal factors by the use of automatic equipment. The application of formulas or procedures such as Feben and Taras have reported may in future provide the foundation for attaining any desired chlorine residual in the distribution system by the use of electronic-mechanical "brains" in the treatment plant.

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Geology and Water Well Construction

By Stuart L. Schoff

A paper presented on Oct. 11, 1949, at the Southwest Section Meeting, Oklahoma City, Okla., by Stuart L. Schoff, Dist. Geologist, Ground Water Branch, U.S. Geological Survey, Norman, Okla.

THE author of contract proposals for a water well is confronted by geologic considerations from the start. Location, depth, casing, screen, size of pump, testing, prevention of pollution, elimination of sand and turbidity—in each of these items some element of geology is involved. As the geologic conditions below any given point on the earth's surface generally cannot be predicted with complete accuracy, approximations to the right answers must suffice, but, without them, the writing of contract documents founders in uncertainties.

The impact of geology is first felt when determining the location of a well. Regional stratigraphic geology is employed to show where rock formations likely to yield the required quantity and quality of water occur. The structure of those formations—including their dip, the folds in them and the faults that cut them into independent, offset blocks—shows the probable location of aquifers which are within the reach of drills and pumps.

Often, of course, the location is selected according to the owner's needs, and the geologist's job is to determine whether a suitable aquifer is present at that place. The exact point to be drilled within a chosen small area occasionally may be governed by geologic considerations, but more often the geologist lacks the detailed information that would enable him to pick one spot in preference to another within the owner's boundaries. He therefore reports merely whether or not a suitable aquifer exists.

The collection of regional geologic information is time consuming and is generally beyond the resources of the individual prospective well owner or municipality. It is, therefore, a task appropriate to the state or federal geological survey.

Regional stratigraphic geology, including the character, thickness and mutual relations of all geologic formations down to the bottom of the chosen aquifer, together with the structure of the formations, is fundamental to the description of the local conditions and the general design of the well to be drilled, but it should be supplemented by local geologic data. Without proper identification of the formation cropping out at the surface on the site, estimates of the depth of the well may become uselessly generalized. Studies of the logs of wells previously drilled in the vicinity are especially helpful in making the local descriptions accurate.

Grain Size

The size of the particles that make up sand, sandstone or gravel aquifers bears on the type of well screen and the capacity of the pump to be used for the well. The size of the openings in the well screen must be chosen carefully if some of the larger particles are to be

kept outside while the smaller ones are pumped from the well. Although the geologist may predict the approximate size of the particles in an aquifer, the best information will be obtained from sieve analyses of the materials bailed or washed from the hole itself. It is obvious that the samples must be selected carefully so that they truly represent the aquifer. Some water well drillers may have sieves for making rough size analyses, but many do not, and too often the size of the openings in well screens is determined by guess.

It might be thought that the state or federal geological survey should provide sand-sieving service to water well contractors, but such a plan would not be very practical. The period consumed in shipping samples and mailing back the analyses, together with the delay in the laboratory if a backlog of samples should build up, could be expensive to the contractor in terms of time lost.

If several water wells are to be drilled for a water supply system, it seems reasonable that the owner—whether a municipality, a privately owned water works or an industry—could well afford to buy half a dozen sieves for making grain size analyses on the spot. Carefully chosen samples of suitable volume, shaken by hand for five or ten minutes, should give a separation good enough to show which is the major grade size. Mechanical shakers would increase the cost appreciably and may not be necessary, but, even including them, the expense would be only a small percentage of the cost of one water well. If this procedure is followed, the contract proposals can be made elastic by suggesting the probable range of screen openings, from which the most suitable size would be selected after sieving the samples.

The larger the particles in an aquifer, the larger the openings between them and, therefore, the greater the permeability, other considerations being equal. Of course, other considerations generally are not equal. A fine sand composed of grains of uniform size will be highly permeable, whereas a deposit of boulders mixed with clay will be essentially impermeable. The permeability multiplied by the thickness of the aquifer gives the transmissibility. The latter governs the rate at which water can be made to enter a well and thus sets the maximum size of pump that may be used advantageously.

Casing and Screen

The degree of consolidation of the rock affects the choice of casing and screen and the development of the completed well. A casing of large diameter will be required for a gravel-treated well in loose sand or gravel, but a much smaller diameter may be quite satisfactory in moderately consolidated beds, and in some formations casings will not be needed below the surface string required for sanitary reasons. If the casing has to be driven into the formations, it must be of greater strength than if it can be lowered into an open hole. Therefore, advance knowledge of the degree of consolidation of the formations to be penetrated, and of the drilling method to be employed, may enable the writer of contract documents to achieve a measure of economy by adapting the casing to the geologic conditions.

The length of casing used in a well is determined partly by the necessity for preventing the entrance of polluted surface waters but also by the extent to which the formations cave into the well. Consider, for example, a deep well penetrating a succession of water-bearing sandstones interbedded with shales, all sufficiently consolidated to stand without casing except the third from the

bottom, which is a loose, fine-grained, "runny" sand. Either the well must be bottomed above the "runny" sand, sacrificing the water to be obtained from the two sandstone layers below it, or the "runny" sand must be cased out, probably by sinking a string of otherwise unnecessary casing to the bottom of that sand, if not to the bottom of the well.

The A.W.W.A. "Standard Specifications for Deep Wells" (1) recognize the importance of consolidation of rock materials by suggesting that well screens are needed for unconsolidated formations only. The reasoning is obvious: Formations that will slump into the drillhole must be prevented from doing so or there will be no well. This objective is accomplished by means of a casing, but, if the casing is blank, the desired water cannot enter. The answer is a well screen, which may be defined as a perforated casing. This definition, however, is much simpler than the engineering that should go into the construction and selection of suitable well screens. The kind of material used in the screen and the diameter of the screen are governed by the same factors that govern the choice of casing. For maximum yield of water, the length of the screen should match the thickness of the aquifer, and its position in the well should correspond with the depth of the aquifer below the surface.

Water Quality and Circulation

The soluble minerals in an aquifer determine the chemical character or quality of the water, which may be worthy of consideration when the casing is specified. If the cost of the casing is not a major factor, its durability and probable length of service are. Consequently, a casing made of a material that will not deteriorate rapidly under the influence of the substances dissolved in the water should be selected. Although it is not a geologist's job to analyze water, he may properly correlate such analyses with their geologic sources and indicate in advance what the chemical character of the water from a selected aquifer probably will be. The analysis will show the engineer whether the water is suitable for its intended purpose, what kind of materials are best adapted for use in constructing the well and, perhaps, the materials the pump should be made of.

The chemical quality of the water depends also on the hydrology of the aquifer. If the circulation of the water through the aquifer is rapid enough so that the water is underground only a short while, it will be fresher than if it stayed underground longer. Given time enough, the circulating ground water will take up the soluble minerals. Such flushing action may explain why the water in some aquifers is fresh for a few miles down the dip but, with increasing distance from the outcrop, becomes too highly mineralized for use. Circulation, of course, means movement of the water, and implies outlets to the surface, as through springs. The pumping of ground water obviously speeds the circulation and may improve the quality, provided that the pumping is not so heavy as to hasten the movement of the poorer water of the aquifer toward the wells.

The quality of the water may dictate the length of the casing. For example, poor water from a shallow aquifer may have to be cased out to prevent the contamination of good water from a deeper one.

Yield and Pump Selection

The hydraulic characteristics of an aquifer are inescapably related to familiar geologic characteristics—the size, uniformity and arrangement of mineral

grains, the thickness of the water-bearing stratum, the presence or absence of an impervious confining layer and the structural connection of the aquifer with the intake area. These geologic factors set practical limits on the ability of rock formations to yield water, and the last two determine whether the ground water is under artesian pressure or occurs under water table conditions. In terms of wells, limits are set on the height to which water will rise in the casing, if it rises at all; the drawdown that will be caused by pumping; the specific capacity; and the well spacing that should be adopted if minimum interference is to be achieved.

Pumps, whether for testing or developing the well or for day-to-day production of water, should be specified in sizes appropriate to the abilities of the aquifer and the well. It is wasteful to install a pump that is too large. Furthermore, too large a pump may lead to well damage through overpumping. Of course, no pump need be larger than is necessary to provide the desired quantity of water, regardless of what the maximum capacity of the aquifer and the well may be.

The selection of pumps is hardly a geologic matter. Rather, it is a job for the consulting engineer or the municipal engineer, and it is definitely out of the province of the geological survey. The geologist, however, may quite properly indicate what yield to expect from properly constructed wells in a given aquifer, leaving the engineer to work out the details accordingly. The geologist must make his prediction from the performance of other wells in the same formation, or perhaps in similar formations. Where this information is fairly common knowledge, the engineer often does his estimating without bothering the geologist.

Pumping tests should run long enough to make it plain that the well and the aquifer are adequate to furnish the required water, and this adequacy, of course, goes straight back through the hydraulic properties of the aquifer to its geologic characteristics. The objective generally is to pump at some specified rate long enough to stabilize the drawdown, but this condition must often be approximated because the drawdown may increase indefinitely, although usually at a progressively lower rate as time goes on.

The performance of a well tapping water in coarse, clean gravel under water table conditions will differ greatly from that of a well in fine-grained sandstone under artesian conditions. With such distinctions in mind, the engineer can specify a reasonable minimum duration for the test pumping. He must also pay attention, of course, to the desirability of developing the well until the water is free of sand and turbidity. In some unconsolidated formations, it will be found that more pumping is required for this purpose than for testing the performance of the well.

Conclusion

Knowledge of the geology of a proposed well site, including facts on the thickness, character and structure of rock formations and on the movement of water in them, is fundamental to the preparation of water well contract proposals. The more accurate the geologic information, the better the proposals can be made to fit the conditions and the more economically the work can be accomplished.

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1. Standard Specifications for Deep Wells—4A.1–1946. Am. Water Works Assn., New York (1946); Jour. A.W.W.A., 37:913 (Sept. 1945).

Applying A.W.W.A. Deep Well Standards

By Paul Schweitzer

A paper presented on Oct. 25, 1949, at the Virginia Section Meeting, Roanoke, Va., by Paul Schweitzer, Pres., Layne-Atlantic Co., Norfolk, Va.

SINCE the days of Abraham and Isaac man has found it necessary to dig holes below the surface of the earth to extract the waters secreted there by nature. The Bible relates how Moses, while leading the children of Israel out of bondage into the Promised Land, took his staff and, with the aid of some occult specifications, smote the rock and produced life-giving water.

The science or craft of well digging was known and practiced centuries before bridges, cathedrals, dams, highways and aqueducts were even dreamt of. Yet, although standards have been applied to such structures for hundreds of years, it was not until the present decade that any attempt was made to draw up a set of specifications which might be followed in the planning, construction and development of water wells for municipal and industrial use.

This deplorable situation came to a close on April 30, 1945, when the Board of Directors of the A.W.W.A. tentatively approved the "Standard Specifications for Deep Wells" (1). These standards were the fruits of the combined efforts of a committee judiciously chosen for this most commendable task. Unfortunately, however, there are a few engineers, consultants and water works men who, either through ignorance or neglect, have not availed themselves of this valuable document.

The specifications are prefaced by the following paragraph: "These 'Standard Specifications for Deep Wells' are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned."

The committee preparing these specifications acknowledged the fact that a large municipal or industrial water well to be drilled at any given point was always an important and essentially unique engineering problem.

The construction of a modern water well is no longer the simple task of drilling a hole of a given diameter in the earth for a given distance. The specifications used by Abraham and Moses are no longer adequate. Many states have enacted legislation requiring certain construction features in municipal and public water supply wells. Some states have found it necessary to restrict the amount of water that may be extracted from wells in a certain area, in order to conserve the supply. These efforts to standardize and regulate the construction of water wells result from the necessity for protecting the health and convenience of the citizens.

If underground conditions were identical or even similar everywhere, if all aquifers were of the same character, and if all subsurface water were of the same quality and not subject to contamination, there would be no problem in developing specifications and maintaining standards of well construction.

Unfortunately, this happy situation does not exist. Therefore, the engineer undertaking the construction of a substantial ground water supply must thoroughly acquaint himself with all known subsurface formations at the well site and make adequate provision to solve successfully all unforeseen and unpredictable conditions that might be encountered.

The problem of every engineer charged with the design and construction of a well is simply this: to construct a well that will efficiently produce for the longest period the most water of the best quality available at the site in question.

Importance of Geology

The first step in planning the development of any important municipal or industrial well water supply is to assemble all the available data from the state or federal geological survey. Much valuable information and practical advice can usually be obtained from water well drillers and contracting firms that have successfully completed wells in the immediate or similar areas. If little or no accurate subsurface data can be found for the area concerned, the drilling of a test well at or near the site of the desired well to determine the location, extent and nature of the water-bearing formations is highly practical. Water samples from the various strata should also be taken at the time the test well is drilled. This procedure will furnish the engineer with an indication of which water-bearing formation or formations contain the best quality of water.

When all of this information has been assembled, the engineer can make practical use of the A.W.W.A. deep well specifications, which cover nearly every type of well. Usually they need only be modified or combined to meet local conditions in order to develop the most practical and efficient well.

The use of these specifications should not in any way influence the engineer against exercising sound, practical judgment in designing and constructing the proper well for the conditions and circumstances prevailing. The construction of a gravel-wall well in consolidated formations, or the development of a deep limestone well where a better quality and more copious supply of water could be obtained from comparatively shallow sand and gravel aquifers, is an obviously ridiculous procedure. Nevertheless, many wells have been improperly designed and constructed, to the cost of municipalities and industries and the detriment of the well-drilling profession.

Practical use and proper application of the A.W.W.A. deep well specifications will reflect honor upon the designing engineer and result in financial benefit to the users of well water supplies.

Reference

1. Standard Specifications for Deep Wells—4A.1–1946. Am. Water Works Assn., New York (1946); Jour. A.W.W.A., 37:913 (Sept. 1945).

Well Cleaning With Calgon

By John P. Kleber

A paper presented on Oct. 11, 1949, at the Southwest Section Meeting, Oklahoma City, Okla., by John P. Kleber, Sales Engr., Dept. of Munic. & Process Waters, Calgon, Inc., Pittsburgh, Pa.

THE use of vitreous or glassy phosphate * in the "threshold treatment" of municipal and industrial water supplies to control corrosion, prevent lime scale and stabilize iron- or manganese-bearing waters has become widespread during the past decade and is familiar to most water works engineers and operators. A more recent and somewhat less familiar application of glassy phosphate in the water works field is its use, in considerably higher concentrations than in threshold treatment, for the cleaning of old wells to restore their pumping capacities and for the initial development of new wells to provide greater capacities in the beginning.

Well cleaning with glassy phosphate is a natural outgrowth of other applications in which it has been successfully employed for many years. The gradual dispersion and removal of calcium carbonate and loose iron deposits in water systems with threshold treatment is well known. The concentrations of glassy phosphate which are thus employed, however, are chosen primarily for the prevention of such deposits rather than for the rapid removal of those already present. Much higher concentrations of glassy phosphate—on the order of several thousand parts per million—have long been used in industrial processes chiefly concerned with dispersion. Examples of such processes are the deflocculation of clays and pigments in the ceramic, paint and paper industries; the use of oil field drilling muds; and the selective flotation of ores. The dispersive properties of glassy phosphate which make these applications possible indicated that this chemical might prove valuable for the cleaning of water wells where the restriction of flow was caused not only by substances deposited from the water, but also by clay, silt or various inorganic minerals present in the strata. If the latter proved to be true, the employment of glassy phosphate would present definite advantages in efficiency over the use of inhibited acid.

Procedure Employed

With these thoughts in mind and drawing from experience in other applications, it was possible to set up a well-cleaning procedure using glassy phosphate which proved successful on its first trial. Further experience has suggested minor changes which are embodied in the method described in this paper. The procedure consists simply of adding to the well a solution of 100–200 lb. of Calgon (16 lb. per 100 gal. of water in the well casing), together with 20 lb. of calcium hypochlorite—

* The glassy phosphate referred to in this paper is Calgon, which is characterized by a P_2O_5 content of 67 per cent.

the latter to kill iron bacteria and other organic growths which are frequently present in wells—while the deep well pump and all other equipment are left in place. The chemicals are allowed to remain in the well for 48 hours, and the pump is turned on and off ten or twelve times at four-hour intervals in such a manner that the water is raised to ground level and then allowed to drop back into the well. The resultant churning action is necessary both to provide the agitation which is required in the dispersion process and to force the glassy-phosphate solution out into the strata. In the 16-in.-diameter wells of New England, this agitation is provided quite effectively by means of compressed air. The well is then flushed thoroughly to waste before it is returned to service, and the entire procedure is repeated until no further improvement in drawdown or capacity is noted. Normally, only one or two charges of phosphate and hypochlorite are required.

Field Tests

One of the first field tests of glassy phosphate for well cleaning was conducted in 1943 at the Shell Oil Co. refinery at Wood River, Ill. (1). As many of the wells there had porous concrete casings, acid treatment was obviously not feasible, and the severity of the problem is evidenced by the abandonment of 25 wells between 1917 and 1943. The results were so promising in the initial well cleaned that the treatment was extended to 20 others, both concrete and gravel packed, with similar success in each instance. A marked increase in capacity was obtained in every well, and in all but a few the original capacity was equaled. This company now charts the drawdown of all wells and cleans them on a routine basis at six- to twelve-month intervals, depending upon the rapidity of the increase in drawdown. Previous to this program, in one group of 24 wells, the average well life had been approximately five years. Periodic cleaning with glassy phosphate has now maintained the capacity for more than five years and has apparently prolonged well life indefinitely.

Since these original trials were made, this method of cleaning wells has been successfully used in all parts of the continent and in all types of wells, including radial water collectors. Most operators report that the initial capacity is restored and often exceeded. The method has proved equally effective whether the plugging was due to precipitated iron and calcium carbonate or to silt, clay, amorphous silica and similar substances which are obviously not affected by acid. Some operators have become so enthusiastic about this treatment that they have applied the cleaning procedure to other problems, such as plugged sand filters and cation-exchange softeners, with good results reported.

It should be pointed out that this method of well cleaning is not a cure for all well troubles, since it has been found that the treatment will not disperse and remove the larger particles of fine sand which may be causing the drop in pumping capacity. As far as is known, bailing and mechanical removal are the only remedies for this condition. Fortunately, the plugging of wells with sand is comparatively rare, as evidenced by the fact that glassy-phospate treatment has failed in less than 3 per cent of all of the wells cleaned to date.

Advantages of Method

Careful observation of field results over a period of years provides definite

evidence that glassy phosphate is the most effective agent yet developed for restoring the capacity of water wells when the well screen or the water-bearing strata around the well, or both, have become plugged with mineral deposits. Its greater effectiveness compared with inhibited acid is not at all surprising when one examines the nature of the minerals removed from the well during the cleaning operation. A few typical examples of these deposits are given in Table 1. These examples were not selected on the basis of geographical distribution but were chosen only to show the wide variety of substances that have been removed by the treatment. Some of the minerals, such as calcium carbonate and iron oxide or carbonate, would have been dissolved quite effectively by acid, but the majority would not have been affected. In one well at the chemical plant in southern Illinois, treatment with inhibited acid resulted in a capacity of only 400 gpm. Not satisfied with this figure, the plant officials then cleaned the well with glassy phosphate and the capacity immediately rose to 1,200 gpm., a 200 per cent increase.

TABLE 1

Suspended Matter Flushed From Wells

Location	Major Constituents	Minor Constituents
Chemical plant (Delaware)	Kaolin, mica or hydromica	Quartz, iron oxide, cristobalite
Chemical plant (southern Illinois)		
Well No. 1	Amorphous silica	Calcium phosphate, hydrated ferric oxide, calcium carbonate
Well No. 2	Hydrated ferric oxide	Calcium carbonate, calcium phosphate
Well No. 3	Iron carbonate, calcium phosphate	Feldspar, calcium carbonate, calcium sulfate
Well No. 4	Calcium carbonate	Ferric oxide, feldspar, quartz, calcium phosphate
Well No. 5	Quartz	Ferric oxide, amorphous silica, calcium carbonate and phosphate
Industrial plant (near St. Louis)		
Well No. 1	Quartz	Particles of clay, ferric oxide (sulfide odor)
Well No. 2	Quartz, amorphous silica	Hematite
Well No. 3	Hematite, hydrated iron oxide	Magnetite (sulfide odor); many bacteria present, including sulfate-reducing type
Municipality (Illinois)		
1st flushing	Quartz	Magnesium silicate, calcium carbonate, ferric oxide
2nd flushing	Magnesium silicate, calcium carbonate	Ferric oxide, quartz

In addition to its greater effectiveness, glassy phosphate presents certain other advantages over the use of acid. Unlike acid, glassy phosphate is

quite harmless to either metal or concrete during the short contact periods employed. Therefore, wells can be cleaned leaving the equipment in place without risk of shortening its life. This results in reduced labor expense, and the low cost of glassy phosphate in the amounts required also yields material savings. Moreover, the chemical is safe to handle and no obnoxious or dangerous fumes are generated in its use.

Because glassy phosphate is effective in dispersing mud, clay and other substances, it has been found of considerable value in the initial development of new wells. Capacities are increased and substantial savings in time and labor can be realized. In at least one instance, an industrial plant in South Carolina, the use of this treatment prevented the abandonment of a badly needed new well which had been drilled at quite an expense and was producing little more than a trickle of water.

Periodic cleaning appears to be more convenient and economical than attempts to maintain well capacities by continuous glassy-phospate feeding. It is difficult to apply this treatment to a water-bearing stratum or well screen continuously, although it has sometimes been done by means of feeder wells which surround the producing well.

The use of glassy phosphate in well cleaning supplements and extends the benefits of this treatment to the entire water system. Threshold treatment aids in maintaining the capacity of the distribution system and consumer services, while periodic cleaning with glassy phosphate maintains the well capacity.

Reference

1. Andrews, G. N. Chemical Cleaning of Porous Concrete Wells. Jour. A.W. W.A., **39**:729 (Aug. 1947).

National Utilities Radio Committee Report

The National Committee for Utilities Radio has published "A Guide to the Preparation of Individual System Rules," intended to aid the management of utility radio licensees in complying with the FCC requirement that "some type of standardized operating procedure" be adopted for radio communication. The document, approved unanimously by the delegates present at the annual meeting of the N.C.U.R. on March 17, 1950, will be distributed to each licensee in the Power Radio Service through the ten regional utility radio coordinating organizations, which have records of all licensees in their respective districts (*see* October 1949 Journal, pp. 904–05).

The Guide, a 20-page mimeographed booklet, consists of "typical operating instructions" and "typical operating procedures," including such items as form of messages, code signals, routing of traffic and the like.

Occupational Health Hazards

By William H. Cary Jr. and Peter J. Valaer

A paper presented on Nov. 4, 1949, at the Chesapeake Section Meeting, Washington, D.C., by William H. Cary Jr., Director, and Peter J. Valaer, Industrial Hygienist, both of Bureau of Public Health Eng., Dist. of Columbia Health Dept., Washington, D.C.

GOOD health is a positive condition, not just the absence of infection or injury. Too often health protection problems are regarded from a negative viewpoint. The mere avoidance of the spectacular illnesses or injuries, which may result in the severing of limbs, searing and burning of body surfaces, acute pain or even death, does not afford the individual the protection which is necessary for the preservation of good health. The day-by-day accumulation of poisoning by the heavy metals, the fragmentary but invisible disintegration of vital organs—such as liver destruction by the halogenated hydrocarbons—or the gradual, invisible accretion of silica dust in the lungs is just as important. Because such insidious agents are slow to act, because they are nonspectacular in immediate result, they frequently receive small mention or are given little thought in the consideration of health protection.

The purpose of this paper is to enumerate some less known or less often considered factors and situations which may be health hazards, in order to furnish at least a partial check list. Every water plant should be examined by an industrial hygienist for these and other possible hazards. It must be realized that the list given in Table 1 is by no means complete and, conversely, that not all of the hazards mentioned will be found in every water works.

The protection of workers against industrial health hazards cannot be a sporadic undertaking but must be made a matter of routine. Because many of the dangers, such as the inhalation of vapors from degreasing tanks, are invisible and cause no immediate pain, workers tend to become indifferent to exposure. Safeguards, such as protective clothing or masks come to be considered a nuisance and are discarded or carelessly used. More positive means of control are therefore recommended. Better working environment, the substitution of nonhazardous or less hazardous materials, and the use of improved or different techniques are all ways of achieving positive results.

The general environmental health factors of importance in a working area are: lighting, heating, ventilation, sanitary facilities, clothing lockers and eating accommodations. Good lighting is essential to the maintenance of the employees' eyesight and brings tangible benefits in the form of increased efficiency, better housekeeping and lower accident rates. Lighting is especially important in drafting rooms, offices and laboratories, but every department deserves consideration. The criteria for good lighting include not only adequate

TABLE 1—*Water Works Health Hazards*

Where to Look	What to Look out for	What Might Happen	What to Do
Chemical treatment	Chlorine Sulfur dioxide Ammonia	Chronic or acute respiratory irritation, possibly fatal	Ventilation; personal respiratory protection*
	Caustic soda Lime Lime-soda Sulfuric acid	Burns and dermatitis	Careful handling; protective clothing
	Lime Lime-soda Sodium fluoride	Inhalation of dust, with irritation or poisoning	Ventilation; personal respiratory protection*
	Hydrogen fluoride	Burns and poisoning	Special handling to be worked out in detail before use
	Sodium chlorite	Fire	Special handling to be worked out in detail before use
Auto body and fender repair	Lead	Inhalation or ingestion of dust	Personal respiratory protection*; personal hygiene
Degreasing	Carbon tetrachloride Trichloroethylene Leaded gasoline	Poisoning by inhalation or absorption	Ventilation; substitution of nontoxic solvent
Calking pipes	Lead	Inhalation	Ventilation
Custodial work (disposal of fluorescent tubes)	Beryllium Mercury	Poisoning through cuts and by inhalation	Ventilation; gloves; personal respiratory protection*
Clearing of weeds	Poisonous plants	Dermatitis	Protective clothing
Fire extinguishers	Halogenated compounds	Respiratory irritation and poisoning	Substitution of nontoxic chemicals
Chemical laboratory	Various factors	Inhalation; ingestion; contact	Exhaust hoods; cleanliness; good technique
Bacteriological laboratory	Heat and humidity from sterilizers	Chronic discomfort	Ventilation
Painting	Lead Benzene Other solvents	Poisoning by inhalation or ingestion	Ventilation; personal respiratory protection*; personal hygiene

* Personal respiratory protection refers to respirators and gas masks as prescribed by an industrial hygienist for specific purposes; not to be used routinely, but only in emergencies or during infrequent operations where ventilation cannot be provided.

TABLE 1 (*contd.*)

Where to Look	What to Look out for	What Might Happen	What to Do
Welding	Ultraviolet light Infrared rays Zinc Lead Nitrogen oxides Hydrogen fluoride Dust	Conjunctivitis; dermatitis; metal fume fever; poisoning; pulmonary edema Respiratory irritation	Goggles; face shields Ventilation
Garage forge	Carbon monoxide	Subacute poisoning; asphyxiation	Ventilation
Machine shop	Cutting oils	Dermatitis	Protective ointments; personal hygiene

* Personal respiratory protection refers to respirators and gas masks as prescribed by an industrial hygienist for specific purposes; not to be used routinely, but only in emergencies or during infrequent operations where ventilation cannot be provided.

illumination levels but freedom from glare and avoidance of excessive contrast. Heating and ventilation are usually closely related. Temperature, relative humidity and air movement are all important to bodily comfort. The provision of adequate sanitary facilities, clothing lockers and eating places offers the workers the opportunity to exercise the proper personal hygiene necessary to the preservation of good health.

Treatment Plant Hazards

Probably the best known chemical hazards in water works operation are introduced by the compressed gases used in water treatment. Continued exposure to relatively small concentrations of chlorine, sulfur dioxide and ammonia may result in chronic irritation of the upper respiratory tract. Acute exposure can be serious or even fatal. Ventilation of rooms where compressed gases are kept or used might well be provided in two stages: [1] a continuous low rate for removal of gas from small leaks and [2] high-capacity ventilation for flushing out the space when a break occurs. The latter should obviously have dual control—a remote switch, as well as one in the immediate vicinity. Protection of electric motors from corrosive gases must be provided, as motor failure in an emergency can be disastrous. It should be remembered that exhaust ventilation is ineffective if there is no supply of fresh air to replace that removed. Sufficient gas masks of the proper types should be available at strategic locations. Only those masks which have Bureau of Mines approval should be used.

Sulfuric acid, caustic soda solution, lime and lime-soda are capable of burning the skin. Dermatitis from lime and lime-soda is well known, and the breathing of lime dust may give rise to respiratory irritation. These hazards can be minimized by careful handling and by the use of protective clothing. Proper exhaust ventiliation can eliminate the possibility of breathing dust.

Where fluoride is added to drinking water, special attention must be given to the handling of this toxic material, regardless of the form used. Some plants are employing liquid hydrofluoric acid, which can produce serious burns.

The hazards of the laboratory are

numerous but are probably not dangerous where the personnel is competent. The laboratory should never be overlooked in an industrial hygiene survey, however, as even the best chemists may become overconfident from the daily handling of dangerous chemicals.

Maintenance Hazards

Calking of pipes with lead is a hazard if the lead is melted in a confined space. Melting should be done in the open air, or exhaust ventilation should be provided.

The hazards of general maintenance work are most likely to go undetected. Any painter is subject to lead poisoning by ingestion if personal cleanliness is not practiced. Spray painters must be protected by suitable respirators or preferably by adequate exhaust ventilation.

Welders may be exposed to excessive amounts of infrared and ultraviolet radiation, and to a variety of gases, fumes and dusts. Personal protective equipment must be used, and ventilation must be provided when the welding is done in a confined space.

Carbon monoxide is an infamous killer which may be encountered near the forge, in the garage or wherever combustion takes place. Exhaust ventilation properly applied can remove this threat. It is worth noting that 6,000 cfm. of general exhaust ventilation is required for a single motor vehicle, whereas, if local exhaust is employed by connection with the tail pipe, 150–200 cfm. is sufficient.

The garage mechanic may be exposed to lead through contact with ethyl (leaded) gasoline, in the use of metalizing spray and in grinding off lead filling in body and fender work. In the latter two tasks, the workmen can be protected with suitable respirators. In the garage, electrical shop and machine shop, excessive concentrations of toxic vapors may arise from the use of synthetic solvents for cleaning or degreasing metal parts. Such work should be done in the open air or in a degreasing tank having specially designed ventilation and operated in an approved fashion.

Carelessness in the use of cutting oils in the machine shop may cause dermatitis. This condition can be prevented by frequent washing and by the use of protective ointments. Protective ointments or gloves may also be required for crews employed in removing weeds around reservoirs, as poison ivy and other toxic plants will most certainly be present to some degree.

The electrician or custodian who removes and disposes of burned-out fluorescent lamps should be informed of the beryllium and mercury hazard involved and must be given explicit instructions for their safe disposal. Fire extinguishers should be selected with regard not only to their efficiency in fighting fires but to the gases and vapors generated by their use. Extinguishers filled with carbon tetrachloride, methyl bromide or other halogenated compounds should generally not be used because of the health hazards involved.

Conclusion

As volumes could be and have been written on most of the hazards mentioned, these sketchy comments are by no means complete or conclusive. New techniques will bring new problems, and water works hazards can be expected to change from year to year. Some of the recent discoveries in atomic fission and allied fields may change present concepts of water treatment. More imminent, perhaps, is the use of new solvents and chemicals whose toxicities are not known today.

Good industrial hygiene involves not merely the removal of a few gross hazards but the exercise of constant vigilance over many small items as well. Recently a dozen men collapsed from carbon monoxide poisoning in a certain plant. As a result of this accident, the management, in addition to removing the gross hazard, took positive steps to eliminate as far as possible all traces of this dangerous gas from the workrooms. But it should not require a major disaster to force protective action, because, in the presence of industrial health hazards, workers may be sacrificing a small part of their lives each day without anyone being the wiser.

Revision of Cation Exchanger Manual

Revisions of Table 3 and Sec. 15.4.1 and 15.4.3 of the "Tentative Manual of Cation Exchanger Test Procedures—5Z-T" were approved by the Committee on Water Works Practice on March 20, 1950. The new form of these sections is given below:

TABLE 3

*Brining of Exchangers**

Cation Exchanger	Brining and Displacement Time† *min.*	Nominal Exchange Capacity *grains per cu.ft.*	Salt		Vol. of NaCl required for 1,550-ml. unit *ml.*
			lb./cu.ft.	*me/l*‡	
Greensand	35	2,800	1.26	0.345	602§
High-capacity greensand	45	5,500	2.48	0.680	1,187§
Synthetic siliceous	60	11,000	4.95	1.36	2,375§
Coal derivatives	60	7,000	3.15	0.86	1,502§
Resin, phenolic base‖	60	7,000–15,000	3.15–6.75	0.86–1.85	725–1,560#
Resin, polystyrene base‖	60	25,000–30,000	11.25–13.50	3.08–3.70	2,596–3,119#

* Salt shall be applied at the rate of 0.45 lb. per kilograin of hardness removed. If salt economies are to be stressed, lower salt doses may be employed, but at lower exchange capacities, as guaranteed by the manufacturers.

† The displacement rinse is a volume of raw water applied at the same rate as, and following, the brine and is used for rinsing the brine from the exchanger so that all parts of the exchanger shall receive equal contact with the brine.

‡ *See* footnote, p. 14.

§ Volume of brine based on 5 per cent solution (0.888 *N* NaCl).

‖ Present experience indicates that a 10 to 15 per cent sodium chloride solution is more satisfactory for the resins than a 5 per cent solution.

\# Volume of brine based on 10 per cent solution (1.839 *N* NaCl).

Sec. 15.4—Salt Solution

15.4.1. *Quantity:* Table 3 summarizes the volumes of cp. sodium chloride solutions required for sodium exchangers of different types for this standard laboratory test. The quantity may be varied, however, for particular tests.

15.4.3. *Strength of Solutions:* The salt solution shall be made from tap water to a strength of either 0.888 *N* (5 per cent) or 1.839 *N* (10 per cent) by weight of salt (NaCl), the strength selected to be in accordance with that shown in Table 3 for the type of cation exchanger under test.

Practical Safety Measures

By Robert L. Jenkins

A paper presented on Nov. 3, 1949, at the Chesapeake Section Meeting, Washington, D.C., by Robert L. Jenkins, Chief, Safety Div., Office of Chief of Engrs., U.S. Army, Washington, D.C.

SUPERVISORS and operators are generally convinced of the desirability of accident prevention, but many of them are engaged in a continual search for a means of producing safety on the job without obligating management to lead the way. This search will always be fruitless. Accident prevention depends largely on individual attitudes, and the most potent forces in shaping attitude are leadership and instruction. When the man at the top begins to think in terms of safety, he will be establishing the foundation for a proper attitude throughout his organization. The next step is to get everyone working at it.

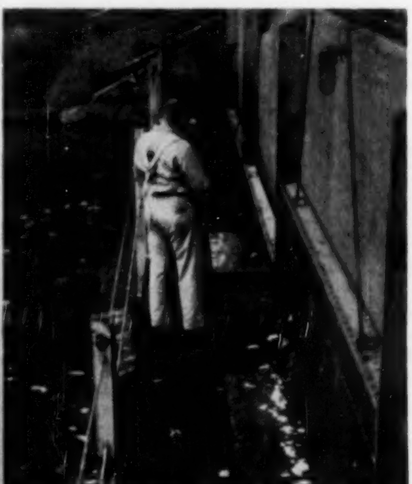

FIG. 1. Manual Cleaning of Intake Screens

One of the most frequent blunders committed in developing a safety program is to set it up as a separate entity, as something extra added to the regular duties and responsibilities of the employees, with special rules and regulations superimposed upon the everyday operating requirements. The basic mission of a water works is not to produce a good safety record but to provide an uninterrupted supply of good water as economically as possible. The value of a safety program rests solely on the contribution it makes toward accomplishing this mission. Consequently, the safety controls should be integrated with every operation, whether it be design, construction, purchasing, hiring or any other. By the time this kind of safety program reaches the man on the job it has become a part of the environment and of normal practice.

FIG. 2. Completely Enclosed Screens

Accident causes include faults in arrangement, mechanical failures, need-

less exposure to risk and acts of God. Because accidents are so often related only to the man on the job, the fundamental sources are obscured. The common practice of classifying causes as either unsafe acts, or unsafe conditions, without reference to attendant factors, has much to do with this deficiency. A casual glance at the above list suggests that two or more of the items probably contribute to every accident.

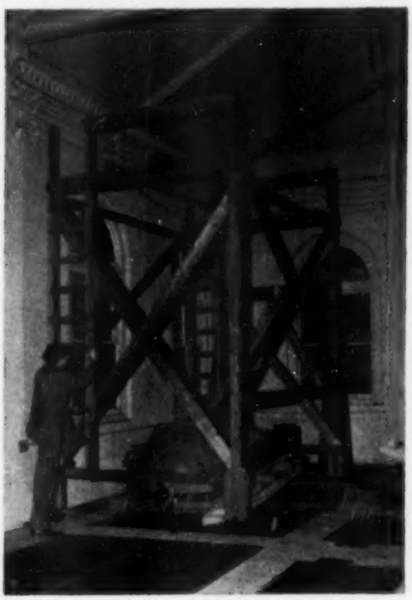

FIG. 3. Movable Wooden Scaffold

FIG. 4. Light-Weight Metal Scaffold

The most prevalent cause of accidents is faults in arrangement. Although proper arrangement will prevent most mechanical failures and needless exposure to risk, it often receives the least consideration. For example, Fig. 1 illustrates a condition of high risk for personnel who must clean the trash racks and screens at a pumping station intake. The working platform cannot be adequately guarded without unduly hampering the operation. This arrangement invites and encourages workmen to expose themselves unnecessarily to risk. In order to protect against the hazard, a wire lifeline has been provided above and to the rear of the platform, and lines from lifebelts worn by the workmen are attached to sliding rings. It is a standard operating procedure at this plant for anyone going on the platform to don a belt and snap the lifeline to the ring. Figure 2, however, shows an arrangement which completely controls the risk: the screens are entirely enclosed and are cleaned without hand labor.

When working from a small boat, the greatest risk, of course, is drowning. This hazard can easily be controlled by equipping all persons so exposed with buoyant work vests. A boat hook should also be within easy reach, to rescue people from the water, fend off floating objects or aid in landing. All reservoirs should be provided with ring buoys and lines strategically located

so that they may be tossed to anyone in the water. In addition, reservoir personnel should be instructed in prompt and proper rescue methods and in means of resuscitation. The American Red Cross will gladly provide such instruction on request.

A movable scaffolding, such as that shown in Fig. 3, is a considerable improvement over working from ladders. The wooden type depicted still offers exposure to many risks, however, as it is cumbersome to move, impedes access to a considerable area of floor space and is subject to strains. Moreover, it must be disassembled before moving it to another building, inviting the usual hazards of demolition, as well as the possibility that members will be misplaced or omitted during erections. The scaffold illustrated in Fig. 4 is vastly better. The members are made of light-weight alloy, permitting easy disassembly, portability and erection by one man. Although easily rolled where needed, it is securely held in working position by wheel locks. A stair has replaced the ladder for ascending and descending and guard rails are built in.

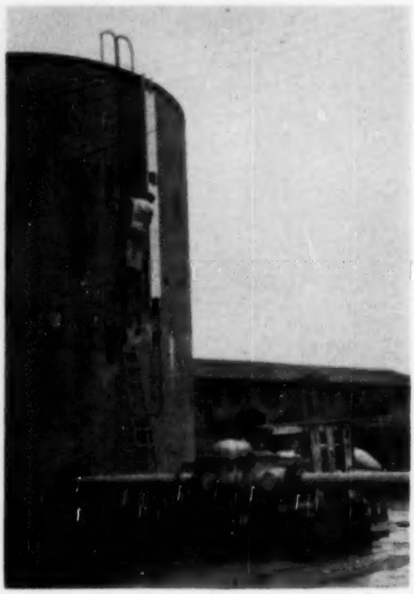

Fig. 5. Hazardous Ladder

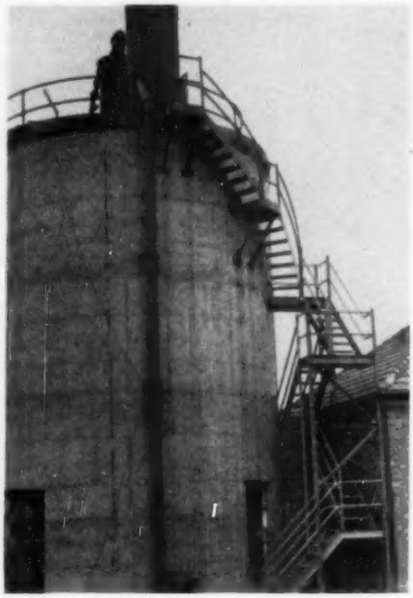

Fig. 6. Stairway Arrangement

Vertical ladders represent a typical access problem which breeds many accidents. They should be considered only as a last resort, especially in locations where frequent use is required. If they must be employed, they should be caged, the rungs should be offset to prevent slipping and grab rails should be provided for a secure handhold when getting on or off. The shaft should be well lighted and the opening completely guarded, whether the ladder is in use or not.

Figure 5 illustrates an arrangement which is difficult to justify. If the man should fall, it would no doubt be determined that his carelessness was the

cause, yet no other means have been provided for him to climb up. In Fig. 6, the problem of access has been given full consideration, a safe stairway being provided to the top and intermediate points. Many ladders might thus be replaced by stairs. In fact, the opportunity for profitably improving access arrangements throughout water works is tremendous. Employees are hired to perform certain operations which require them to move about, and their productiveness is directly dependent upon the rate at which they move. Nevertheless, management sometimes creates conditions which defy a reasonable rate of movement. Where the workmen should be able to operate with normal motions, they are forced to climb, straddle, stumble, leap, stoop, crawl or slide in order to do their job.

An arrangement for the safe handling of chlorine tanks is shown in Fig. 7. No hand labor is required in the transfer from truck to cradle. The power feed rail for the hoist is covered, and the supports are striped for high visibility. The well equipped chlorine room can quickly purge fumes with exhaust fans operating through automatic louvers. Electrical fixtures and equipment should be vaporproof, and a cabinet housing self-contained emergency breathing apparatus can be placed outside the door.

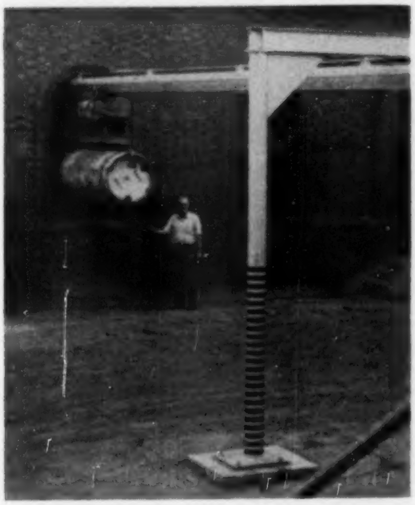

Fig. 7. Safe Handling of Chlorine Tanks

Figure 8 illustrates a typical indoor transformer vault. The spotless appearance is evidence of excellent housekeeping, but all bus bars are exposed and oil pits with quick drains for leakage disposal are not provided. Ventilation must be induced through the rear-wall louvers to prevent a high temperature rise. In the event of a breakdown, the units would have to be moved from the vault by hand. An outdoor installation is shown in Fig. 9. The switchgear and instruments are completely enclosed in the metal panel cabinets, which are each provided with a handle lock on the door. Bus bars and potheads are protected from the elements

Fig. 8. Indoor Transformer Vault

and shielded from accidental contact with maintenance personnel. All connecting cables are enclosed in underground ducts and vaults. Oil spillage readily drains from the mounting slab, and cooling is provided by the ambient temperatures.

Figure 10 illustrates several features of arrangement worthy of note. The compact, high-efficiency vacuum cleaner is easily rolled about and is employed for general cleaning purposes throughout this pumping station. In the photograph it is being used to clean a motor. The gallery around the motor is completely equipped with railings. The port in the pumpshaft housing has a transparent plastic window, serving as an effective guard and yet affording complete visibility. The original lighting system has been augmented by additional units strategically placed.

FIG. 9. Outdoor Transformer Installation

These typical illustrations should be convincing proof that practical safety is within the easy grasp of any water works operator. Of even greater interest, however, should be the extent to which safety-inspired improvements contribute to getting the job done. It is an ordinary occurrence to find that the production benefits of such improvements completely overshadow the safety benefits. And that is exactly the way it should be.

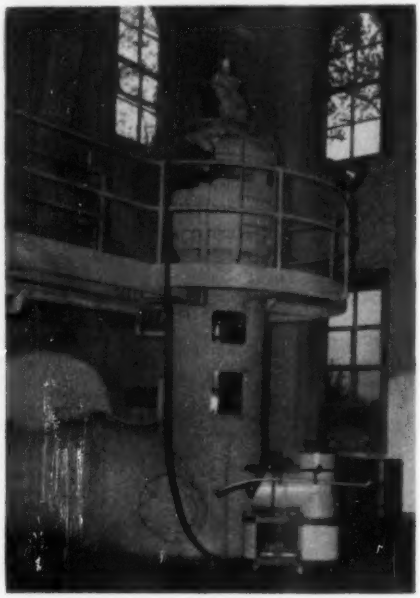

FIG. 10. Pumping Station Safety Features

A sincere and continuing demonstration of safety leadership by management and the unified efforts of administrators, operators and craftsmen toward attaining the common safety objective for each activity provide a bedrock foundation for any safety program. Creating a safe environment and then inducing all concerned to respect it is the way to practical safety.

Public Relations in a Small Water Works

By John C. Luthin

A paper presented on April 1, 1949, at the Arizona Section Meeting, Prescott, Ariz., by John C. Luthin, Supt., Water Dept., Santa Cruz, Calif.

EVERY utility manager or superintendent, whether he thinks so or not, is conducting a public relations program which acts constantly to add or detract from the esteem of the public for the utility. Everything that is done in the normal conduct of the business produces either a favorable or unfavorable reaction. It is the summation of these reactions that results in an overall good or bad relationship between the utility and the public. Conversely, these contacts offer the best and most natural means of improving that relationship. A complete public relations program can be developed by taking advantage of each contact between the utility and the public to better the public's respect for the utility. Having studied the possibilities for bettering public relations, a review of the utility's attractive features and facilities, and the talents of its personnel, can be the basis for a well planned program.

The essence of a good public relations program is the feeling, radiated from within, that the utility is operated in an efficient and businesslike manner. The program is manifested by instilling in the minds of the public the assurance that they are receiving the best product and service that can be reasonably expected and that the charges are commensurate with the service rendered. The public is primarily interested in obtaining a safe, palatable water, together with good service, rendered at a reasonable cost. No matter how elaborate a public relations program is in force, it will be ineffective if the quality of the water and service is not good. The service is generally comparatively easy to perfect, but the palatability of the water cannot always be improved and often handicaps the maintenance of good public relations.

Aside from these unheralded features, there are the more spectacular aspects which go beyond the silent public relations program. These include displays showing attractive facilities, the preparation of literature for the education of the public, the production of a moving picture and the use of other advertising media. Although a very useful part of some public relations programs, such items cannot all be included in the program undertaken by a small utility.

The manager should, by all means, speak before clubs and civic groups, but, unless he is endowed with a natural eloquence, it is best that talks be made only at appropriate occasions and for a real purpose. The same note of caution applies in the matter of pamphlets prepared for public consumption. The proper use of this medium will be beneficial but an amateurish attempt merely for the sake of making the program complete may do more harm than good. On the other hand, the press can always

aid materially in bringing interesting facts and happenings to the public. A friendly newspaper will be very receptive to requests for publicity, and the reporter can generally take the facts given him and write a story with the necessary personal appeal. Consequently, it behooves every utility to maintain a good relationship with the press.

These larger aspects of the public relations program must receive careful attention. The salient points and suggestions for developing these features are well covered in the Association's "Silent Service Is Not Enough" series. By and large, a simple, wholesome program will serve adequately, but a utility blessed with attractive facilities and talented personnel may well take advantage of its attributes.

Responsibility of Manager

The focus of the small utility's public relations program is its manager. He is inevitably well known in his community by virtue of his position and the natural interest in the public water supply, and he cannot escape responsibility for the impression made on the public by himself, his employees and the facilities of the water works. He is looked upon as the one who directs all of the operations, and his ability and attitude are reflected in the work of his employees and the public's attitude toward the general activities and programs instituted by the utility.

Perhaps the most important assets of a successful utility manager are a thorough knowledge of the water business and the ability to convey to his employees and to the public the assurance that he has the capacity to meet all situations and provide service economically. The manager should be conversant with the quality, treatment and distribution of water, the rules and regulations governing the furnishing of service, the accounting and financial controls, office procedure, methods of handling complaints, the construction of pipelines, the installation of services and all other aspects of the business. He should know how his rates, regulations and billing practices compare with those of other water utilities and how they are received by the public. He should also know how the appearance and arrangement of his office compares with others. If his water supply requires elaborate treatment processes, he should be thoroughly familiar with the purposes and effectiveness of each phase and should know whether his plant is as efficient and effective as other, similar plants.

The manager need not be a technical expert on all of these matters, but he should certainly be sufficiently well informed to command the respect of his employees and the public and be able to convey his ideas and purposes to them. Much of this desired information is readily available to him and can be acquired with little effort. The state health authorities and regulatory bodies render a service in advising and informing utility operators on water quality and financial control. Visits to other utilities and attendance at water works conferences are also worth while.

Problems which require particular technical skill should be worked out by experts. The expense is well justified not only as a means of obtaining the information, but also because it signifies to the public that the best possible methods are being used to maintain a good quality of water and service. The accumulation of working knowledge by the manager as a way of commanding

respect as an expert guiding force in the business of furnishing water service cannot be overemphasized.

Employee Contacts

Although the manager is looked upon by the public as the personification of the utility, the employees have far more contacts with the customers. They can, themselves, and through their families and friends, undo all of the achievements of the manager if they are not properly suited and trained for their jobs. The entire personnel should be made to feel the responsibility of playing a part in furnishing the public with good water service. They should recognize the potential hazards to the safety of the water and the need for treating the water and preserving its quality from the source to the customer.

Assigned duties should be given some meaning, and the employees should be made to feel the significance and importance of their performance as a part of the whole scheme of operation. Time should be taken periodically by the manager to review the work with the individual employees in order to emphasize its purpose. If the employee is imbued with the feeling that he has a definite part in a business enterprise, he will take more interest in his work and will convey this interest to his home and friends. An employee who likes his work and feels a responsibility for doing it well is one of the utility's best envoys of goodwill. Among the important factors in keeping up the employee's morale are a specific job with well defined responsibilities, a reasonably good salary and provision of the best equipment consistent with the type of work and the principles of economy.

The man in the field has relatively little direct contact with the public, but his actions and attitude do have some effect on public relations. In the course of construction, repair or replacement of water lines, the foreman and workers should be considerate and courteous in such matters as informing customers of temporary interruptions in service and other inconveniences required by the work. The public should be protected from damage, and, when the job is complete, the site should be left in good condition, with damaged property repaired, all surplus material removed and ditches properly filled and surfaced. The field men should be cautioned against attempting to explain main extension rules or other policy matters and should refer the persons making such inquiries to the office.

Meter Readers

The meter reader plays an important part in the public relations program where meters are installed in the basements of homes and access must be gained through the house. Under those circumstances, the men generally wear uniforms and must be particularly well adapted to their jobs. In the Southwest, where meters are at the curb, the meter reader has much less contact with the public but he should nevertheless go about his work industriously and should be instructed to answer questions on meter reading and to explain to customers how to read meters if they request it. When the meter reading is unusually high, it is good practice to inform the customer, so that he can repair the leak or adjust his consumption immediately.

Office Employees

The office employees who deal directly with the public, and the appearance of the office itself, are of particular

importance in the public relations program. Very often the only contact a customer has with the utility is when he signs for service or pays his bills, and his casual observation of the office makes a lasting impression on him. The office should, therefore, have an appearance that exemplifies good management. It should be clean and orderly and provided with modern furniture and equipment in reasonably good condition. All superfluous items and noisy equipment should be kept in other rooms. All customer records should be conveniently stored in modern filing cabinets. Forms should be designed so that they may be quickly made out and should call attention to the information desired. Copies of rate schedules, regulations and other information for public use should be kept close to the counter.

In a small utility, the clerk at the counter or window also has other duties to perform. Such employees should have a type of work assigned to them which can be dropped instantly, so that people at the counter are not obliged to wait until it is convenient to serve them. A utility office is subject to more critical scrutiny by the public than that of most other businesses, and the customer is as likely to be provoked at seeing idle personnel as he is at having to wait until a busy clerk finds it convenient to talk to him. To avoid this difficulty as far as possible, the clerk should be located near the counter, should not have to answer the telephone, should work facing the counter and must recognize that his primary duty is to serve the public.

When feasible, there should be two windows or sections of the counter, well marked—one for collections and the second for service and other time-consuming matters. A map of the existing distribution mains should be available to the person taking applications for service, so that he can quickly determine if there is a main at the location for which a service is desired. Clerks working at the counter should be thoroughly acquainted with matters relating to obtaining and discontinuing service, meter reading and individual customer accounting. They should spend a reasonable amount of time answering customer inquiries.

The fees and deposits required of applicants for service should be predetermined fixed amounts, collectible at the time of application. Making nuisance charges is poor practice and is generally being eliminated. Estimating final bills so that they may be paid when discontinuance of service is requested saves time and expedites closing transactions. Customers making service complaints or inquiries which cannot be answered correctly and positively in a few words should be informed that the matter can best be settled by a field investigation, and the clerk should tell them that a service man will call at their convenience.

Service Men

One of the most important contacts with the public is made by the service man. His prompt response to calls will demonstrate the utility's desire to investigate and correct all irregularities. The manner in which the service man answers complaints will have a very definite effect on the customers' confidence in the utility. Most complaints are made in good faith, and the customer is entitled to a complete investigation of the matter. He should be correctly informed of the findings, and, if the utility is at fault, the trouble should be promptly corrected. If the

condition is beyond the control of the utility or is harmless and not readily remediable, the customer should be so informed. The proper approach to handling complaints is not to pacify or favor the customer but to reach an equitable settlement of the issue.

Handling Complaints

The problem of dealing with complaints is often a difficult one for a small utility and the method of answering some of the more prevalent types warrants some discussion. The most common complaints concern taste and odor, dirty water, low pressure and high bills. It will generally be found that complaints result from changes in conditions rather than from long-standing deficiencies. When due to the latter, complaints of tastes and odors or poor pressure can be answered immediately, once the circumstances are known, and the number of calls can be reduced by having the local newspaper run an article explaining the difficulty. Sporadic complaints will usually warrant an investigation and complete explanation to the customer.

Tastes and Odors

Complaints of tastes, odors and foreign matter in the water, other than those arising out of a general condition, should be carefully investigated. It is well worth the manager's time and effort to answer the more serious calls himself. The findings are varied and unpredictable. If the trouble can be corrected, the customer should be so informed and the condition remedied. When such things as organisms from open reservoirs are observed by the customer, they should be identified and the occasion for their presence in the water explained to him. Nothing disturbs the customer more than the inability of the experts from the utility to identify the foreign matter or to give a reasonable explanation for its presence. Generally, the only service which can be rendered in such situations is to assure the customer that the foreign matter is harmless and is common to certain water supplies. It is important to convince the customer that the utility properly treats the water and checks on its quality throughout the system by laboratory tests.

Low Pressure

Low-pressure complaints fall into two categories: those in the distribution system and those on the customer's premises. Fluctuations and serious drops in distribution system pressure can best be ascertained by the use of a portable recording pressure gage. If the poor flow is due to a constriction or the use of pipe which is too small, a few tests will locate the trouble and demonstrate it to the customer. By connecting a hand pressure gage to the several hose bibs on the premises, opening other faucets and timing the flow through the meter, the location and extent of isolated constrictions can be easily found. If there is still any doubt whether the service pipe is faulty, the meter should be disconnected and a flow test run, to make sure that the meter itself is not the cause. If the service and the customer's pipelines are both deficient, the utility should offer to replace the service after the customer has replaced his piping.

High Bills

High-bill complaints cause the greatest concern and are the most difficult to dispose of to the mutual satisfaction of the utility and the customer. The best

approach is to assume that the customer was not aware of the loss of water and is entitled to a satisfactory explanation, with recommendations on how to prevent a recurrence. The least desirable method of handling this type of complaint is to make a refund without investigation or change the meter and hope that the next bill will be normal.

In answering such complaints the service man first obtains the meter readings for the past several months. He then reads the meter, computes the consumption since the last reading and projects it over a regular reading period to determine whether the consumption has returned to normal. If it has not, the service man calls on the customer and makes a thorough inspection of the plumbing fixtures, particularly the water closet, noting the leakage. He should attempt to estimate the rate or, better still, measure it by timing the meter, to compare it with the excess shown on the disputed bill. If the leak is in a concealed or buried pipe, it can best be localized with the aid of sound-amplifying equipment. Once the cause for the excessive consumption is found, the customer is told how to correct it.

Unless the bill is excessively high, the customer will generally be satisfied and pay the full amount. Sometimes, however, there is good justification for making allowances on high bills. Large leaks occasionally go undetected, resulting in bills which are greater than what the customer can reasonably be expected to pay. When this situation occurs, the customer should be required to repair the leaks before any consideration is given. If an adjustment is made, the general practice is to charge him the amount for normal use plus one-half the excess. There will be times when exceptions must be made to any rule established, but, contrary to expectations, the practice of making allowances on unaccountably high bills does not materially affect the number of protested bills.

Conclusion

A public relations program, when broken down into its elements, becomes a multitude of seemingly trivial practices which, common sense indicates, should be a natural part of the activities of any properly conducted business. Such a program is indeed an integral segment of the general utility operations, with emphasis on making use of the points of contact with the public as a simple means of advertising the service being rendered. A careful analysis of these elements and the development of a solid, wholehearted respect for the utility by the public will result in benefits to the utility that cannot be purchased. The goodwill engendered can easily surpass that achieved by competitive enterprises which spend large sums for advertising. The day-by-day accomplishments in building up the public's confidence will not only bring the intangible reward of satisfaction to the operator but provide material support during bond elections and protect the privately owned utility from abuse or confiscation.

Increasing the Efficiency of Meter Reading

By Wendell R. LaDue and Edward E. Smith

A joint discussion presented on Nov. 3, 1949, at the Ohio Section Meeting, Dayton, Ohio, by Wendell R. LaDue, Supt. & Chief Engr., Bureau of Water & Sewerage, Akron, Ohio, and Edward E. Smith, Gen. Supt., Dept. of Water & Sewage Treatment, Lima, Ohio.

Akron Methods—*Wendell R. LaDue*

It is recognized that no two cities handle the reading, changing and repairing of meters in the same manner. This discussion is therefore limited to the procedure used at Akron.

In order to obtain flexibility in assigning personnel and to increase their duties and responsibilities, which results in a correspondingly higher civil service classification and a higher wage scale, Akron trains its metermen to read, repair, test and change meters, to make other minor field repairs and pressure, leak and use surveys, and to turn services on and off.

Akron is divided into 450 permanent routes, of which about 400 are active, each containing approximately 175 customers. Every route is laid out alphabetically by street and numerically by house number, and is set up in the same order as the customer ledger and addressograph plates. In establishing the permanent routes, it was clearly recognized that, regardless of the prescribed method of covering them, the meter readers would follow the most convenient or quickest paths. Consequently, no effort was made to direct the walking. On the inside cover of each route book is a sketch of the area and a list of the streets and limits. The meterman is thus given complete information and latitude in setting up the most efficient manner of reading.

Reading Sheets

Each reading sheet has a rectangle representing the house and indicating the location of the meter and the entrance to be used. If a curb setting is employed, the fixed location is shown so that it can be found if covered by snow or otherwise concealed. In addition, penciled memorandums are made, noting trees, hedges and other points of reference. Appropriate notations pertaining to the use of keys, the presence of vicious dogs and other useful information complete the record. All new meter-reading sheets are prepared from addressograph plates, which carry the name, address and account number, thus effecting a substantial saving of labor in their preparation.

The meter reader, although not required to record actual calculations, makes a mental subtraction in order to compare current and past usage. If he finds the reading abnormally high or low, a check is made with the customer to determine the cause. Frequently the reader inspects the water outlets in the dwelling or tests the meter at both high and low flows to see if it is operating satisfactorily. The re-

sulting information is placed on the reading sheet for the benefit of the billers, thereby eliminating many calls for rereading or checking the cause of the abnormal bill.

Billing Cycle

As the meter is, fundamentally, the cash register for the business office, these reading operations are closely tied to the billing and collecting of accounts. When cycle billing is used, naturally, cycle reading follows. Akron is divided into nine districts, each billed quarterly on a ten-day cycle. Approximately 7,000 bills are placed in the mail on the first, eleventh and twenty-first of the month. Both billing and meter reading are linked to these dates. To illustrate, for the mailing on the twenty-first, the billing must start on the eleventh and the meter reading on the first of the month, thus allowing ten calendar days for each process. This procedure has the advantage of making the maximum time between meter reading and receiving the bill twenty days—sixteen, on the average—which has proved very beneficial in the rendering of final bills when the turnoff occurs a few days subsequent to the receipt of the bill. Customers pay without question a bill including sixteen days of back usage but object strenuously if the back usage approximates 30 days.

Meter Reading Calls

Only two calls are made to get a reading. If the reading is not obtained on the first call, a postage-paid card is left, containing a dial on which the customer is requested to indicate the location of the hands. Since many domestic customers have $\frac{3}{4}$- and 1-in. meters instead of the usual $\frac{5}{8}$ in., and since three makes of the latter size are in use, it is necessary to have five different dial cards. Instructions on the card indicate that it should either be mailed in or left at the entrance for the meter reader, who will pick it up on the date shown.

If the reading is not obtained by the reader on the pickup date or by mail, and if the previous bill was computed from an actual reading, a bill is rendered based on estimated consumption. The reading for the next quarter follows a similar pattern, except that, when the previous bill was estimated and the reading is not obtained, a generously estimated bill is rendered, both to protect the utility against leakage and to entice the customer to the office if he considers the charge too high. Arrangements are then made not only for a current reading but for future ones as well. If a reading is not obtained for the third consecutive quarter on the first call, a final notice, which incorporates a dial card and allows five days to furnish the reading, is sent by first-class mail. This notice is rigidly followed up, and, if a trip is required, either a reading is secured or the water is turned off, whether someone is present or not and regardless of the season of the year.

Before the installation of this procedure, two regular pickups and special trips on Saturday mornings were made to gain admission where previous calls had failed. The second pickup and the Saturday trips have been eliminated.

As a result of cycle reading, most of the work is performed in the first five to seven calendar days of the ten-day period. For the remainder of the time, approximately fifteen men repair and test the meters; one man, using a truck, makes collections or turnoffs; several men, with trucks, change meters which have stopped or which require recon-

ditioning either because of length of continuous installation or amount of registration.

Three men are occupied at all times in servicing customers by installing and removing meters, making inspections for high bills, performing minor repairs in place and shutting off service for emergency repairs.

Akron's metermen were recently placed on a 40-hour week, consisting of five eight-hour days, with all working Monday through Friday, except five who work Tuesday through Saturday. One man of four, on a weekly rotating basis, works a split shift, two nights from 4:00 to 12:00 P.M. and on Sunday and two weekdays from 7:30 A.M. to 4:00 P.M. The evening and Sunday work is of an emergency nature, its purpose being to investigate reported leaks on water lines and to handle service calls from customers.

Industrial Meters

The servicing of industrial meters is performed by separate crews, two taking readings and five repairing and testing. Industrial meters, arbitrarily so named, include: (1) all sizes showing an average registration in excess of 50,000 cu.ft. per quarter; (2) all meters 1½ in. and larger, regardless of consumption; and (3) detector check valves. Meters averaging more than 1,000 cu.ft. per day are read weekly, those from 500 to 1,000 are read monthly and the remainder, semiquarterly.

Single-dial meters classified as industrial are read for billing purposes by the domestic metermen on the regular routes. Other readings are performed by the specially assigned metermen, as are all readings for multiple-dial meters. The purpose of these frequent readings is to keep track of meter registration in order to check the development of faulty meters and to obtain actual data pertaining to water use. Such information is employed in settling disputed bills and in making estimates for periods where readings were unobtainable due to stoppage.

The effectiveness of Akron's program must be measured by the smoothness of operation as indicated by the lack of complaints. Using this as a gage, the system undoubtedly is proving effective, since the number of complaints from customers has dropped noticeably year by year during the past decade.

Lima Experience—*Edward E. Smith*

Lima, Ohio, has approximately 13,000 meters, divided into three zones. Meters are read quarterly, except for 150 which are read every month. Three men read a total of 4,100–4,600 meters a month, averaging 10–12 per hour during a five-day work week. The men are transported from the distribution division shop to the working area by an automobile, which is also used by the senior meter reader to make pickups and monthly readings. The route books are examined by the foreman and the clerk of the distribution division to determine nonworking meters and lay out reading routes.

Substitute meter readers are supplied by the distribution division in the event of illness or vacation of regularly assigned readers. The distribution division shop provides garage and mechanical facilities for the meter reader's

automobile and remedies improperly set meters or flooded curb settings.

Meter readers are not designated as such, but are classified as distribution division employees, with the title, "Construction and Maintenance Worker, Class *A* or Class *B*," depending on salary, which, in turn, is based theoretically on seniority and experience.

The greatest difficulty encountered at present is delay or irregularity in submitting meter books. This cuts down the time available for preparing the bills, which must be mailed by the first day of the month so that the customers will receive them soon enough to take full advantage of the "nonpenalty ten days" provision.

The usual reasons for slowness in meter reading are bad weather, illness, failure to report for work and holding of meter books for pickups and examination.

This trouble should be easy to correct but no disciplinary measures are possible under existing civil service regulations unless the civil service board, in practice, upholds formal charges prior to suspension or dismissal of the offending employee. The present regulations, which are incorporated in the city charter, provide "for suspension by the appointing authority for purposes of discipline for a period not to exceed 30 days at any one time. The appointing authority must submit to the Civil Service Board satisfactory reasons for suspending an employee and a suspended employee may have a hearing. The decision of the Civil Service Board shall be final and suspensions shall not be consecutive." Since the board revoked the suspension of an employee for having been "drunk on duty," no effective use has been made of this power.

It was suggested by the author that a "skip list" be attached to each meter book to facilitate pickups, but the suggestion was not followed. Orders have been given that curb meters should be read regardless of weather conditions, but the metermen decline to do so in severe weather. Without a change in the attitude of the civil service board, it appears hopeless to issue orders for the improvement of meter reading, but the "suggestions" will continue.

Selection and Maintenance of Water Meters

By Jens I. Duus

A paper presented on Oct. 20, 1949, at the Alabama-Mississippi Section Meeting, Jackson, Miss., by Jens I. Duus, Factory Supt., National Meter Div., Rockwell Mfg. Co., Brooklyn, N.Y.

THE selection and maintenance of water meters is always a live problem for the management of every water utility. Meter maintenance really begins with the uncrating of the meter in the receiving room. The methods of handling as well as the type of setting have considerable influence on the subsequent performance of the instrument.

It is recommended that every one concerned with the use of water meters have constantly at his side a copy of the latest A.W.W.A. specifications on the subject (1–5). This may seem like an unnecessary suggestion, but it is remarkable how frequently a copy cannot be found in the meter shop or superintendent's office. The present specifications are the result of several years of painstaking work and should serve as the basic guide for buying and judging the performance of all water meters. The specifications themselves can, of course, be modified to suit local conditions, but their provisions will generally be found adequate for practically all situations encountered.

Attention is called especially to the "Notes" which accompany the specifications. The information contained therein is invaluable as a guide for the proper testing and care of meters. The recommendations are basic in character and can and should be elaborated upon to suit specific conditions.

Meter Testing

Several of the points incorporated in these "Notes" are worthy of emphasis. It is strongly urged that all meter departments be equipped with proper testing apparatus, kept in top condition and periodically checked for correct calibration. The wisest policy is to test all meters before installation. Some facilities should be provided for tests at minimum flow rates, and, in order to save time, several meters may be coupled together or set in multiple-type plants. Sufficient water can then be passed to give one complete revolution of the test dial hand.

Definite rates of flow on which certain accuracy of registration is required are given in the specifications. These rates should be carefully checked during any test run by means of a stop-watch or properly calibrated rate-of-flow indicating device. The old method of testing on a "$\frac{1}{4}$-in." or a "$\frac{1}{32}$-in." stream is not to be tolerated today. The old orifice method will lose accuracy because of wear, and the flow will vary with changes in pressure. Scales are a constant hazard and will give trouble if maintenance is not rigidly enforced. If facilities for testing meters are not installed, it is a good idea when setting the meters to remove the register box and register and check the stuffing box for leaks. This proce-

dure is suggested simply as a precaution, since it has sometimes been found that the nuts may have loosened in transit.

Suitable Alloys

A bronze alloy of 85-5-5-5 is mentioned in the "Notes" as being suitable for water meter use. This alloy should be considered as a minimum requirement with respect to copper and tin content. Some manufacturers use more expensive alloys with higher percentages of copper and tin for internal parts of the meter. For certain corrosive waters, the most suitable alloy may be quite different from these bronzes, and high-nickel or even high-zinc alloys may be advisable. There is no satisfactory method of finding the proper alloy for such localities except by continued observation in service of meters made up with different combinations of metals, until the successful one is found.

Maintenance and Storage

In considering present-day trends in water meter maintenance, it is noted that more and more meter shops are getting away from ordering the small parts of subassemblies and are specifying complete units instead. This trend, it is believed, is economically sound and should react to the benefit of both the user and the manufacturer. For example, the purchase of small gear train parts to repair worn trains requires considerable time and effort in taking the assembly apart, fitting the new parts and reassembling the train. A completely new gear train assembly would save all this trouble and, in the end, would usually result in a more satisfactory unit. The small cost of a pinion or a gear may be misleading in view of the total repair job needed for an old gear train. The same observation applies to registers, discs and, frequently, complete measuring chambers. Many design improvements have been made over the years in unit subassemblies which are completely interchangeable with the old style.

Another interesting trend is the use of batteries of smaller meters for large services instead of large single meters. Several progressive water departments have already eliminated the use of meters over the 6-in. size. The ease of handling the smaller meters and the possibility of removing one meter for repair or some other purpose without interrupting service are strong points in favor of this method. It should be emphasized, however, that a satisfactory battery installation is feasible only when compound meters are used. If single-unit meters are employed in multiple, the small rates of flow will be split still smaller over two or more meters, with consequent loss of accuracy.

Ever since the earliest days of water meters, manufacturers have repeatedly advised that service pipes should be fully flushed to wash away all foreign matter before the meter is put in the line. Yet even today stoppages due to pipe cuttings, sand or other matter are found. In new distribution systems, it is extremely important that this flushing be done thoroughly. The more water which runs through, the less likelihood there is of disc breakage or stoppage. Caution in the use of pipe joint compounds is of equal importance. Screens in meters are not expected to filter out all foreign matter, nor is it desirable that they do so.

In recent years piping installations have not been given the attention they deserve. An unsupported or improperly supported pipeline may amplify the slight sound in a meter to annoying proportions. This condition is primarily the plumber's responsibility but the

water works man should be aware of it, so that the meter is not unfairly blamed for noise. Placing the meter as close as possible to the stop- and waste cock is often helpful in these situations.

The storage of meters, either new or repaired, has been given little consideration. Meters should be stored in cool places and preferably upside down. Hard rubber is a sensitive material, and prolonged exposure to heat in a building without ventilation, such as a closed loft or storage shed, can have damaging results. Excessive artificial heat can be just as bad. Pressure tests will reveal any gaskets or stuffing box packings which may have dried out, and it goes without saying that accuracy tests on meters which have been stored for long periods are extremely important.

Repair Problems

A few suggestions regarding practical repairing may prove helpful. It has been found through experience that simply taking the instrument apart and thoroughly cleaning the complete assembly is very often all that is necessary. In old, badly worn meters, however, it is wise to assemble complete units such as new gear trains and new discs with new half balls, where required.

Some progressive water works men have a fixed time for removing meters from service. For instance, a five-year period is a good start for small water meters. Some schedules call for a replacement meter to be installed, thereby causing no interruption in metering. It is suggested that a repaired meter should test at least 90 per cent on a 0.25-gpm. flow.

In an oscillating-piston meter, more clearance between the upper and lower half of the chamber is allowable than in a disc meter, with equal accuracy. Therefore, because the surface may wear a few thousandths of an inch, a new standard piston is all that may be necessary in repairing the chamber.

In the assembly of the meter, it is the author's opinion that only a small quantity of lubricant should be used in the gear train. Anything that will successfully cut down the resistance offered to the disc lengthens the life of the ball socket or bearing in a disc meter, for, when that is gone, the piston drags on the wall of the chamber, with a slackening of registration. This reasoning must hold good whether friction or back pressure is caused by sediment in the water or drag is generated by a semiliquid grease. Along similar lines of thought, care should also be exercised in tightening the stuffing box nut. A good stuffing box assembly holds the water pressure when fingertight. It is wise to treat the cork washers with a graphite solution before assembling them with the stuffing box nut.

The size of the control block, which has a bearing on the clearance between it and the disc spindle, should always be carefully checked. If it is the practice of the water department to repair its own gear trains and the control block is worn, it should be replaced carefully with a new one. Sometimes the disc spindle must also be removed and replaced. If too much clearance is allowed, loss of registration on the lower streams will result.

Again, if it is the practice to repair worn disc half balls by shimming with paper or other material between the discs, it is, of course, necessary to use the same thickness on either side and to clean well before assembling. Fitting and scraping the half ball to suit a possible worn socket is poor practice. More satisfactory results will be obtained by using oversize half balls. The clearance between the chamber ball

socket and the rubber ball can be easily checked. A most simple and satisfactory "gage" is to place a piece of writing paper, 0.003–0.004 in. thick and about ¾ in. square, in the lower chamber socket, assemble the disc and upper half of the chamber, and feel the up-and-down clearance by the disc spindle. The half ball, when gaged in this fashion, should move without any apparent clearance in the ball socket. The use of sandpaper or emery cloth in repairing chamber sockets is discouraged, because the grit embeds itself into the metal and wears away the rubber half ball.

The acid used for cleaning bronze parts should not be too strong, as it may eat away the metal.

Meter Selection

The selection of the correct type of meter is relatively simple, but the determination of the proper size is complicated. It requires careful calculation, together with experience and practical knowledge. Standard plumber's manuals give the capacity of various fixtures in gallons per minute, and the results of simultaneous operation may be estimated. At best, these factors are arbitrary. To ascertain whether a meter already in service is of the proper size, a recording mechanism can be attached to the meter for data on the maximum and average rates of demand. In normal service, a ⅝-in. meter will rarely exceed 5 gpm., whereas this size carries a maximum safe rating of 20 gpm. On the rather infrequent occasions when 24-hour continuous service is encountered, the rule of using one-fifth of the maximum rating for displacement meters should be strictly adhered to. If the meter in question does not conform to these requirements, a larger size must be used. For the current type meter, one-third of the maximum rating is a safe rule. Reliable flow recorders are on the market and their use in checking actual rates of flow on a service is highly desirable.

The following observation may serve as a check on the precision manufacture and accuracy of any lot of new meters, whatever the make: the more change gears a manufacturer of meters finds it necessary to use to get any required test, the greater is the variable of important tolerances in his production. By the same token, the nearer he gets to a single combination of change gears, the better are his precision production methods.

All meter manufacturers should welcome suggestions and criticisms from water works men. Information on difficulties experienced in practice and ideas on how to make water meters more useful will be gratefully received. Only in this way can true progress be made in meter development.

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Effect of Metering on Water Use and Revenue

By R. T. Hosmon

A paper presented on Nov. 1, 1949, at the Kentucky-Tennessee Section Meeting, Lexington, Ky., by R. T. Hosmon, Supt., Utilities, Milan, Tenn.

NO business, regardless of its kind, can hope to succeed without some record of its supply, its cost of operation and its sales. The satisfactory operation of a modern water system, whether privately or municipally owned, involves an accurate record of the amount of water entering the system and the amount consumed. The management must at all times be acutely conscious of and exercise control over waste and leakage. Toward this end, it is well to consider the effects of customer meters on consumption and revenue.

At the outset, a distinction should be made between water consumed—that is, used for a gainful purpose—and water wasted. Experience at Milan, Tenn., indicates that the effect of metering upon consumption is not nearly so pronounced as upon wastage. When a community is placed on a meter basis, however, a slight reduction in consumption occurs, caused primarily by a cautious approach to a completely new and different method of purchasing water. This is a small effect and of little consequence, but there is another factor to be considered. Under the flat-rate method, water is used liberally for sprinkling lawns and gardens, washing the family automobile and other purposes beside the normal sanitary and domestic needs. This type of use, indulged in by a large percentage of the customers paying a flat rate, is noticeably curtailed after meters have been installed. Although there is no practical way of differentiating between water used for this purpose and water wasted, visual inspection before and after metering indicated that, in Milan, fully 80 per cent of the customers refrained from watering lawns after meters were installed and 90 per cent stopped watering gardens. If anything, these estimates are low.

Further light is shed on this matter by Fig. 1, which shows the master meter flow from January 1946 through December 1948, including a period before and since metering. It will be noted that there was a rise in flow during the summer months of 1946, prior to metering, and a corresponding rise in the summer of 1948, but not so pronounced or abrupt as in 1946. It should be recognized that the ordinate difference of these two curves during the summer months reflects a reduction not only in the use of water for lawns and gardens but in wastage as well. It is reasonable to believe that the shape of the curves gives a truer picture of reduced consumption than the numerical values do. (In this connection, the dip in the 1947 curve may be explained by the decreased wastage and more cautious use of water which are immediate consequences of metering.) It is estimated that sprinkling was a common practice among at least 50 per cent of the cus-

tomers before metering but only about 15 per cent since.

The reduction in consumption (gainful use) appears small, however, when compared with the reduction in wastage. In the author's opinion, the greatest single effect of customer meters is the curtailment and control of waste. During the year preceding the installation of meters, the average use in Milan was 135 gpd. per capita. In 1948, the second year of metering, the average use was 75 gpd. per capita, a reduction of approximately 45 per cent.

Referring to Fig. 1, from January to August 1946 the total monthly flow ranged between 20 and 25 mil.gal. After August 1946, when the metering program began, a steady decrease in monthly flow can be noted, continuing well into July 1947. A study of the 1948 curve reveals a leveling off of the monthly flows between 10 and 14 mil.gal. per month. The reduction in flow, clearly indicated by the ordinate separation between the curves for 1946 and 1948, ranged from 10 to 12 mil.gal. per month, or about 50 per cent.

Another interesting feature of Fig. 1 is the rise during March 1947, which reflects the carryover of the old practice of allowing exposed yard hydrants and faucets to run during cold weather to prevent freezing. Although February 1948 also shows a slight rise, it is apparent that this use, while persisting, has been materially reduced.

A study of water use by consumption brackets reveals that the percentage of customers using in excess of 8,000 gal. per month decreased sharply after May 1947, when metering was completed, while the percentage of customers using 2,000–5,000 gal. increased correspondingly. This situation is attributed to the fact that, in the early period of metering, leaks were present in many homes, which caused the water usage to fall within the higher bracket. By late 1948 and early 1949 the two usage brackets began to assume fairly stable relations. From May 1947 through January 1949 approximately 15 per cent of the total customers moved from the larger usage bracket to the smaller, approximately 10 per cent doing so within the first four months. Although complete data on the subject are not available for the period August 1946–May 1947, it is evident from Fig. 1 that a considerable percentage must have made the transition from the higher to the lower bracket during that time.

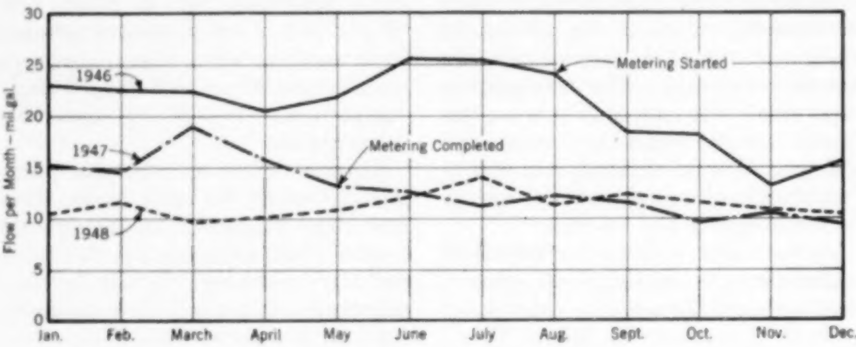


Fig. 1. Milan Water Use, 1946–48

Effect on Revenue

The effect of metering on revenue in Milan was found to be favorable. Gross operating revenues rose from $24,439.11 for the fiscal year ending June 1945 to $36,081.93 for the fiscal year ending June 1948, an increase of 47.6 per cent. As the number of customers did not grow greatly during this period, the increase in revenue can be attributed almost entirely to the use of meters.

Although salaries have shown a general increase since the war, the use of meters has had very little effect on them, since such additional duties as meter reading and testing, customer accounting and bill collecting were assumed by existing personnel.

It will be seen from Table 1 that purchased power decreased from the 1945 peak of $5,355.27 ($446.27 per month) to $3,566.62 ($297.22 per month) in 1948, a reduction of 33.4 per cent. This decrease is obviously related to the reduction in flow indicated by Fig. 1. (When comparing Fig. 1 with Table 1, the observer should bear in mind that the latter is based on a fiscal and not a calendar year.) The interest paid in 1947–49 shows an increase over previous years, which is due to the financing of meter installation. It should be pointed out, however, that the adoption of metering made it possible to refinance the outstanding portion of an original 3 per cent revenue bond issue, together with additional funds for meter installation, at an interest rate of 2½ per cent. The net saving in interest during the remaining life of the bonds is sufficient to offset the original cost of the metering program.

The effect of metering on the surplus may be observed from Table 1. As pointed out in the beginning of this paper, the operation of any water distribution system must be judged on its merits as a business. From this viewpoint, the results of any undertaking show up most vividly in the surplus or profits. In that respect and others, the installation of customer meters in Milan can be considered most successful.

TABLE 1

Yearly Revenue Analysis

Item	Fiscal Year (Ending June 30)					
	1944	1945	1946	1947	1948	1949
	Amount—$					
Operating revenues	22,781.01	24,439.11	25,310.72	32,279.15	36,081.93	37,842.09
Salaries	7,899.33	9,181.43	8,666.81	8,374.03	9,756.34	11,098.59
Power	5,243.30	5,355.27	5,160.50	4,235.49	3,566.62	3,732.64
Other costs	3,249.90	3,363.95	5,608.23	4,760.44	5,661.84	5,300.16
Interest	2,708.26	2,640.00	2,577.00	2,921.39	2,925.04	2,800.08
Depreciation	3,280.20	3,280.20	3,280.00	3,280.20	3,280.20	5,597.83
Surplus	400.02	618.26	18.18	8,707.60	10,891.89	9,312.79

Trench Backfill Practices

By Harmer E. Davis and Fred N. Finn

A paper presented on Oct. 26, 1949, at the California Section Meeting, Sacramento, Calif., by Harmer E. Davis, Director, and Fred N. Finn, Institute of Transportation and Traffic Eng., Univ. of California, Berkeley, Calif. This paper was written before the publication of A.W.W.A. Tentative Standard Specifications for Installation of Cast-Iron Mains—7D.1–T (December 1949 Journal, p. 1079). If any statements in the paper are in conflict with the A.W.W.A. document, they will be taken into consideration by the Committee on Laying Cast-Iron Pipe.

SOME time ago members of the specifications committee of the California chapter of the American Public Works Assn. and some of the staff of the Institute of Transportation and Traffic Engineering at the University of California discussed the problem of the preparation of workable standard specifications for the selection and placement of backfill in service cuts in roadways. Exploration of the problem disclosed a surprising lack of dependable factual information on the characteristics and performance of trench backfills but indicated a rather widespread interest in this subject, at least on the part of engineers concerned with street work in municipalities.

In order to have some basis for a new attack on the specification problem, and in an attempt to clarify the physical problem of controlling backfill materials, a cooperative study was initiated, consisting in its early stages of an examination of existing practices and case studies of selected backfill projects. This paper is a summary of information collected thus far concerning existing practices and presents a brief discussion of some of the factors involved in the backfill problem.

Broadly stated, the essence of the problem is to repair a pavement through which a cut has been made, in as permanent a manner as possible, consistent with reasonable economy and a minimum of public inconvenience. It should be obvious that a number of procedures may be employed to obtain approximately the same result.

The present paper will be confined to that portion of the backfill between an elevation somewhat above the top of the pipe conduit or culvert and the base course of the pavement. Generally, fair to adequate attention appears to be paid to the bedding of the pipe and the backfilling immediately adjacent to it. As a result of the work of Marston and his associates at Iowa State College, most engineers recognize the need for firm, uniform bedment and lateral support of pipe and the reasons therefor. Engineers also generally seem to appreciate the value of an adequate base course under pavement patches.

Only fills in trenches ranging in width from about 1½ to 4 ft. and having a depth from the surface to the top of pipe in excess of 2 ft. will be discussed.

General Practices

Two general procedures are employed for placing backfill in trenches in roadways: [1] tamping of dry to moist soil placed in relatively shallow layers; and [2] use of water to densify loosely backfilled masses of soil. Tamping is sometimes done manually, sometimes by mechanical (usually pneumatic) tampers. On an increasing number of jobs placed by tamping, an attempt is made to compact the soil at a moisture content considered to give approximately the maximum density.

There are several procedures involving the use of water. In "puddling," the soil is pushed into the flooded trench. "Ponding" involves filling the trench nearly to the top with relatively dry, loose soil, after which water is applied to the surface of the lift until the material is saturated. Sometimes small dams of earth are made at intervals along a trench, between which pools of water may be allowed to stand for several hours. At times these pools are made for puddling succeeding lifts. In "jetting," the trench is filled nearly to the top with relatively dry, loose soil, and then a jet pipe is inserted at frequent intervals into the fill. The pipe is forced to the bottom of the lift and is removed when water begins to appear at the top of the lift. In California practice, the usual height of lift is 6–8 ft., although a lift of 15 ft. is not unknown.

There are some variants of these procedures. For example, in the ponding process, holes may be formed in loose backfill by the use of metal rods in order to expedite the penetration of water (a process called "barring" or "rodding").

When water is used to aid in densifying backfill, it is common practice to leave the top of the trench open for one to several weeks to permit the drainage of excess water from the fill. The pavement is commonly patched only temporarily to allow for settlement of the fill to take place over periods up to six weeks or more, before the permanent patch is placed.

It is becoming more common, on fills placed either by tamping or through the use of water, to compact the portions of the fill immediately below the base course by rolling. Either special narrow drum rollers or the rubber-tired wheels of trucks or other construction equipment are used.

Trenches are usually backfilled with the material which has been previously excavated, although in cuts in primary, heavily traveled streets and highways, where the excavated material is definitely inferior for backfill, the use of imported borrow is not uncommon. Generally, an attempt is made to exclude boulders, roots, debris and frozen soil from backfill. It is widely acknowledged that granular (as opposed to cohesive or clayey) materials are preferred, but sands are considered undesirable in locations where a future cut will parallel or cross the trench.

Table 1 summarizes backfill practice in various states, as reflected by the specifications of state highway departments (1). Most states which permit hand tamping specify the weight of tamper and the size of tamping face. Nearly all the states include the requirement "to the satisfaction of the engineer" or the equivalent. This phrase is no doubt necessary when there are no quantitative guides to practice, but it should be noted in passing that its use may imply an admission of lack of good information or lack of care in writing or revising the specification. Moreover, higher bids or troublesome disputes may result.

California requires tamping or roll-

ing in 4-in. layers to 90 per cent relative compaction, based on optimum density by the static (CBR) method or the equivalent field (impact) method. "Should the contractor elect to furnish sandy or granular material for backfill, the 4-in. layer construction may be eliminated and compaction obtained by ponding or jetting" in layers of less than 6 ft. (2). Ponding or jetting is not permitted where the backfill will not compact by such methods to a relative density of 90 per cent, or where the foundation material will soften when saturated.

Survey of California Practice

Inquiries on backfill practices were sent to a number of California cities. Of fourteen cities reporting, two specify tamping, four specify the use of water, six allow either tamping or the use of water, one specifies a combination of tamping with the use of water and one merely stipulates that the backfill be made "to the satisfaction of the city superintendent of streets." Although most of the cities specify the type of material to be used for bedding around the pipe ("fine earth free from large stones"), none of the fourteen attempts to define acceptable materials.

Municipal practice and specifications in California tend to lean preponderantly toward the use of water for densifying backfills, although there is no uniformity in the specification of procedures. Some mention of materials is made in connection with this type of densifying, but only one city gives any description of an acceptable material. Shale is permitted in some areas, as evidenced by reference to "hosing" to be used for backfilling with shale. Specified depths of lift vary from 9 in. to 10 ft. None of the specifications gives an indication of the time a trench should be left open when water is used

TABLE 1

State Backfill Requirements

Requirements	No. of States *
Group A—Specifications requiring compaction but not specifying density	41
Tamping provisions:	
Mechanical tamping only specified	9
Hand *or* mechanical tamping	16
Hand tamping only mentioned	5
Tamping method not mentioned	11
Depth of layer or lift:	
Depth placed before compaction—*in.*:	
4	3
6	29
8	1
9	1
12	1
Depths 4–8 in., but with particular requirements for hand tamping	2
Depth 6 in., but not clear as to loose or compacted	4
Moisture control:	
Some provision	19
No provision	22
Provision for select or approved materials	34
Permission to saturate, flood or puddle	4
Group B—Specifications requiring density control	8
Tamping provisions:	
Mechanical tamping specified	2
Hand *or* mechanical tamping	2
Tamping method not metioned	4
Compaction requirements:	
Not less than 95 per cent max. density (A.A.S.H.O. T99–38)	1
Not less than 90 per cent max. density (A.A.S.H.O. T99–38)	3
Not less than 90 per cent rel. density (Calif. method)	2
Max. depth of layer or lift—*in.*:	
4 (loose)	2
6 (loose)	2
6 (compacted)	2
4–6 (loose)	1
8 (loose)	1
Provision for moisture control	8
Materials requirements:	
Granular backfill specified	2
Select or approved backfill specified	6
Provision for puddling	1

* District of Columbia included.

for densifying, nor is there any minimum period before the final pavement patch can be placed. Some specifications provide that the "trench should be left open to traffic" for some time before final pavement is placed.

Specifications of cities requiring tamping generally set no requirements on the type of equipment, and the permissible depth of layer on lift to be compacted varies from 4 to 12 in. or is not stated.

It is of interest to note that two cities specify the use of a concrete slab extending 6 in. beyond each trench wall for, or under, the resurfacing.

The authors have also endeavored to sample a cross section of actual practice in making trench backfills (in the counties in the San Francisco Bay area) through the inspection of jobs and by interviews with municipal and utility company engineers, job inspectors and contractors. The following remarks are a composite summary of these inspections and interviews.

With close inspection, care and adequate funds, backfills made by mechanical tamping can provide satisfactory support for permanent paving. The cost of this procedure is relatively high but may be warranted where high traffic volumes demand that a roadway be closed to use for as short a time as possible. An important advantage of tamped backfill is that the base course and pavement can usually be placed as soon as the fill is brought to grade. Objections to the tamping method are: [1] the necessity for continuous inspection to get a good, uniform job; [2] the fact that, under light pavements, accidental variations in density may lead to local failure in the line of the pavement patch; [3] high costs. From the limited information available, it appears that the contract cost of placing backfill by mechanical tamping is approximately three times the expense of placing it by water. This comparison is based on the assumption that the native excavated material is satisfactory for backfilling. If select material is brought in, the relative costs may be in a 5:1 ratio. In addition to the direct contract costs, the expense of inspection is generally greater on a job where mechanical compaction is used and properly controlled.

Some municipalities appear to be getting excellent results with backfills made by the use of water, under the following conditions: [1] the employment of backfill materials capable of ultimately attaining suitable density by the wet method; [2] an allowance of sufficient time for the fill to drain, shrink and compact under traffic before the top is brought to grade and paved. In general, the finer the material, the longer must the fill be left open to the action of traffic before final paving. When materials containing clay are used, a period of two to six weeks appears desirable.

Interestingly, observations and field tests have shown that at least some clayey backfill materials, when placed by water, drain and come to equilibrium moisture content as rapidly as the more coarse-grained materials. This rather high permeability for clays may be due to the fact that, when excavated by trenching machines or even by hand tools, clays retain a lumpy structure and thereby act somewhat, like sands when replaced. Furthermore, it was found from a series of samples taken from trenches backfilled by the use of water that the decrease in moisture content tends to be large for the first few days (up to one week) but thereafter is relatively small. For some materials, it may be that a drainage period of one or two weeks will be just as effective as a period of one

or two months. For other materials, it may well be that the longer period is desirable because of the effect of traffic as a primary compactive agent.

There are now a number of contractors who make a specialty of trench work and service cuts in pavements. Some of these men have developed methods and devices which may lead to important improvements and economies in practice. For example, special mobile mechanical tampers have been placed in use which straddle a trench and allow a pneumatic hammer to work to a depth of 3 ft. below the ground surface. The forward motion and each tamp are simply controlled by an operator who rides the machine. Another contractor is using a trench roller which is capable of applying the same unit pressure in a trench as a standard 10-ton machine. This roller can be easily adjusted to reach about 2 ft. into a trench.

Conclusion

Trench backfills present some problems which deserve special attention. Methods of heavier construction are not necessarily the economical ones in this type of work, and it is possible that some attractive savings in municipal costs may be made. Additionally, more expeditious methods may go a long way toward lowering the "public nuisance" aspect of trench jobs.

There are new problems for the soil expert, too. He needs an adequate concept of the way in which load, after various periods, is transferred from a vehicle on the pavement through the backfill to the native ground into which the trench was cut. A practical classification or identification of soils with respect to their usefulness as backfill materials is also necessary.

The current study points up more sharply the nature of these problems and indicates that contributions will have to be made by many persons and organizations before entirely adequate specifications for trench backfills can be written.

References

1. Summary of Requirements for Backfilling of Trenches, Pipe Culverts and Sewers. Highway Research Correlation Service Circular 71, Highway Research Board, Natl. Research Council (July 1949).
2. California Culvert Practice. Div. of Highways, California Dept. of Public Works (1944).

Discussion

Max K. Socha

Engr. of Water Distr., Dept. of Water & Power, Los Angeles.

In excavating and backfilling trenches for pipelines, the primary concern of the utility is to secure proper bedding conditions for the pipe and the distribution of earth and traffic loads; and, in highly corrosive soils, to inhibit corrosion. The methods used should produce the optimum results at the lowest costs. On the other hand, the governmental agencies having jurisdiction over streets are principally concerned with the proper restoration of street grades, adequate support of substructures which may cross the trench and an early restoration of the street surfaces to carry full traffic loads. In their desire to achieve these results, they do not have too much regard for expense since the burden of costs rests on the utility until the street has been permanently resurfaced. This attitude sometimes leads to a clash of opinion between the city engineer and the utility engineers. The interests of the utility and the city engineer coincide

sufficiently, however, so that achieving mutually desirable results can usually be accomplished by a study of the engineering aspects and the preparation of satisfactory specifications governing excavation and backfill.

In the construction of large-diameter pipelines, it is usually necessary to lay the water pipe below all existing or projected storm drain laterals, sewers and underground telephone ducts in order to obtain proper cover and avoid blanking off one side of the street for the service connections of other utilities and sewer house connections. As these large-diameter lines require very wide trenches, the problem of supporting existing underground structures which cross the trench becomes quite serious. Where sewer, storm drain and telephone conduits are encountered within the trench, the agencies having jurisdiction over them usually require a concrete wall support or a reinforced concrete beam structure, supported on concrete columns to a depth below the bottom of the water line trench.

Both of these structures are costly, time-consuming and possibly harmful to the installations supported. The wall type support requires a minimum clearance of 8 in. between pipe and structure, a considerable amount of difficult forming, which makes the concrete prices excessive, and an open hole in the street for a period of five to seven days. These substructures are usually encountered at street intersections and the required open hole delays considerably the restoration of the street to full traffic loads. The very rigidity of the concrete wall itself is felt to be a destructive force on such brittle material as clay tile, cast-iron and concrete pipe, because of the introduction of sheer planes at the point of transition from natural soil support to the concrete bearing.

The reinforced concrete beam appears more economical but requires a minimum clearance of 18 in. between pipe and structure, which, if attained by lowering the grade, more than consumes the saving. Like the wall support, it requires blocking of the street for a considerable length of time and is nearly as rigid as the wall. The use of a precast beam has been suggested but is considered impractical, because the substructures may cross the trench at any angle and each support must have a different length. Furthermore, no practical method has been developed to install a precast beam and assure positive bearing support for either the structure or the beam.

Inundated sand has long been known as one of the most effective means of properly bedding pipe and, if confined, produces bedding conditions nearly equal to that of a concrete cradle support. Consequently, it was reasoned that a confined, flooded sand fill would form an adequate support for substructures and would be less troublesome than concrete structures. A method was accordingly developed for large-diameter pipelines being constructed in Los Angeles, utilizing inundated and vibrated sand to effect the required substructure support.

The method used for placement is shown in Fig. 1. The usual backfill is placed to the springline along the line of the new pipe to within about 3 ft. each side of the structure to be supported. At this point, temporary vertical header boards are placed to the top of the pipe. The intervening space beneath the substructure to be supported is filled with sand to just above the springline of the new pipe, flooded with the aid of jets and consolidated by mechanical concrete vibrators. The second step continues with earth fill along the pipe and sand between the headers,

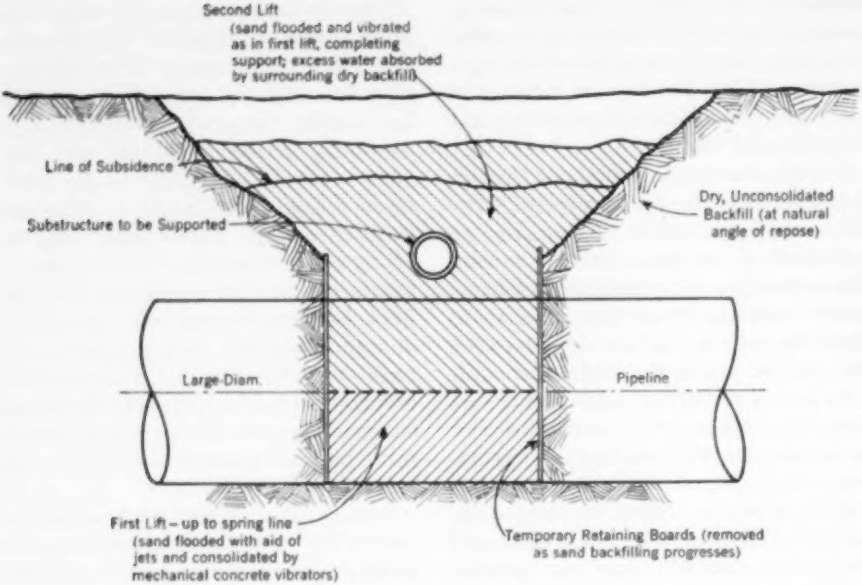


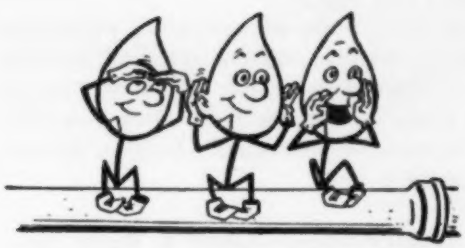
Fig. 1. Method of Placement

carried up more or less uniformly. When both have reached the top of the new pipe, the temporary headers are removed. Dry earth fill is then continued to the street level on both sides, sloped at the natural angle of repose so that the toe of the slope just reaches the sand. The area around the substructure to be supported is next filled with sand to approximately 18 in. above the substructure. The sand is then flooded with the aid of jets, followed up and down with mechanical vibrators. The sand backfill should subside to a level above the springline of the supported substructure, whereupon the trench backfill is completed by the normal procedure. This method allows the support to be placed as a part of the backfill routine, and does not require special handling or the prolonged closing of streets to normal traffic.

Engineers of the Los Angeles Board of Public Works were asked to observe this method of placement, and the city's bureau of standards took samples for compaction tests. Two samples were taken—one near the surface of the sand, the other directly beneath the structure. The former showed 86 per cent compaction and the latter, 100 per cent.

The excess water used in securing ultimate compaction is absorbed by the surrounding dry backfill, and the sand support remains unaffected when the remainder of the common backfill is flooded in the normal manner. The flooded-sand method produced such satisfactory results that it may quite probably be adopted in the city's requirements for the support of substructures.

The saving in cost by using the sand backfill instead of the concrete support will, of course, vary considerably with the type and size of structure and the cost of sand in the particular locality. In the examples cited, the cost of the sand backfill was approximately 30 per cent of that for concrete type supports.



Percolation and Runoff

The Philadelphia Story can't yet be told, but we can give you a clue that this, the 70th Annual Conference of A.W.W.A., is going to set new records in interest, information and entertainment. As noted in the preliminary announcement to all members, there will be a full four and a half days of technical sessions, a full five of social functions and, with 90 exhibitors signed up for 144 booths as of March 30, the biggest and best exhibit ever assembled for the water works field. Add to this the collection of material illustrating public relations at work and water works photographers at work and the opportunity to meet and exchange shop talk with a couple thousand of your fellow water workers and you'll realize why you can't afford to miss it.

Almost everybody's going to be there, and prominent among them will be these new officers and directors who will be officially installed on the last day of the Conference:

President—W. Victor Weir, president of the St. Louis County Water Co. and Missouri Water Co. since 1946. A native of Warren, Ind., he received a B.S. degree from Washington Univ. in 1923 and became junior engineer with the West St. Louis Water & Light Co., predecessor to the St. Louis County organization. He advanced to his present post by way of the posts of engineer, assistant manager, chief engineer, superintendent, vice-president and general manager. He was superintendent, vice-president and general manager of the Missouri Water Co., which operates water utilities in Lexington and Independence, Mo., before assuming the presidency of that firm also. (See frontispiece for photo.)

A member of the Association since 1924, Weir's vigor and drive have led him to become exceptionally active and influential in A.W.W.A. section and national affairs. He has been chairman of the Plant Management and Operating Div., the old Finance and Accounting Div. and the old Missouri Valley Section. Among his committee activities may be counted the chairmanship of the committee on organization and administrative policy

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and membership in committees on water works administration, publication review, national water policy, public relations, meters, graphical symbols, and the revision of the *Manual of Water Quality and Treatment* (now in press). He received the Diven Medal in 1940, the Fuller Award in 1943, and was completing a three-year term as his section's national director when he became vice-president last year.

Vice-President—Albert E. Berry, director of the Sanitary Engineering Division, Ontario Dept. of Health, Toronto, Ont. Born at St. Marys, Ont., he attended the Univ. of Toronto Faculty of Applied Science, receiving B.A.Sc. and M.A.Sc. degrees in civil engineering (1917 and 1921), C.E. (1923) and Ph.D. in sanitary engineering (1926). He is a registered professional engineer in Ontario.

In addition to serving with the Ontario Dept. of Health, which he joined as sanitary engineer in 1919, he has been associate professor at the School of Hygiene of the Univ. of Toronto and during World War I served in the Royal (Imperial) Engineers.

Active in a host of technical organizations, he has been secretary-treasurer of the Canadian Section since 1933, with an interval from 1937 to 1940 when he was its director. Association activities include membership on the publication committee and the committee on joint administration of water and sewer facilities; and the chairmanship of the Water Purification Div. (1935–36) and the Fuller Award society, which he joined upon receiving the Canadian Section's award in 1938.

Treasurer—William W. Brush, editor of *Water Works Engineering*. Brush was born in Orange, N.J., in 1874 and was educated at New York Univ., from which he received B.S., C.E., and M.S. degrees. He served as engineer with the Brooklyn Water Dept. from 1894 to 1907, transferring to the New York Board of Water Supply in the latter year. In 1927 he was appointed chief engineer, and served in that capacity until 1934. In that year he began his present affiliation with the Case-Shepperd-Mann Publishing Corp. and *Water Works Engineering*.

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His reelection as treasurer continues an unbroken record of over a quarter-century of high office in the Association, for, except for a two-year interval in 1928–29 when he was successively vice-president and president, Brush has been treasurer since 1922. In that time also he has been active on many A.W.W.A. committees, and has served ex officio as a member of both the Board of Directors and its executive committee. He received the John M. Diven Medal in 1932 and in 1937 was made an honorary member.

Continuing with new members of the Association's Board of Directors, the additions will be:

Alabama-Mississippi Section—Arthur N. Beck, chief engineer and director, Bureau of Sanitation, Alabama State Health Dept. Born in Hazlehurst, Ga., in 1905, Beck received his degree in civil engineering from Alabama Polytechnic Inst. in 1928, going on much later to receive the M.S. in engineering from Harvard in 1937.

A registered professional engineer in Alabama, Beck served with the Atlantic Coast Line Railroad on construction projects from 1923 to 1925. He joined the State Health Dept. in 1928 and worked on rural sanitation until 1934, when he was assigned to the Div. of Water Supply and Sewage. He was appointed director of the sanitation bureau in 1946.

An A.W.W.A. member since 1938, Beck served as secretary-treasurer of the organization committee and later was chairman of the Alabama-Mississippi Section. He received its Fuller Award in 1948.

Arizona Section—John A. Carollo, consultant of Headman, Ferguson & Carollo, Phoenix. Born in Diamondsville, Wyo., in 1906, he received degrees of B.S. from Notre Dame and M.S. from Massachusetts Inst. of Technology. He is a registered professional engineer in half a dozen states.

After completing his education in 1928 he joined the Ohio Oil Co. in Salt Lake City, Utah, as chief draftsman. His next post was that of chemist in charge of sewage treatment for Pontiac, Mich., and then he went abroad to study European sanitary practice.

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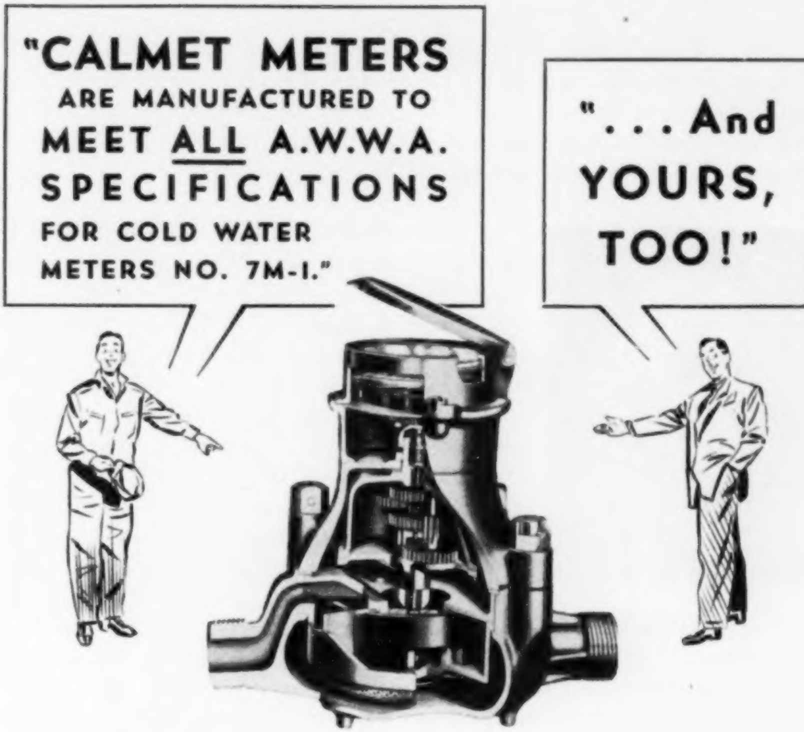

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In 1929 he joined the Chicago consulting firm of Pearse, Greeley & Hansen as assistant engineer. He became a member of the firm with which he is now associated in 1933. Active in professional societies, he has been president of the Arizona Section, American Society of Civil Engineers, and of the Arizona Sewage and Water Works Assn.

Chesapeake Section—Harry B. Shaw, deputy chief engineer, Washington Suburban Sanitary Commission, Hyattsville, Md. Born in Frederick, Md., in 1899, Shaw received a B.S. degree in civil engineering from Johns Hopkins Univ. in 1920 and is a licensed professional engineer in Maryland. His affiliation with the suburban Washington organization began in 1920 and continued until 1926, when he resigned his post of assistant to the chief engineer in order to work on various construction projects, including real estate, sewage and water works. He returned to the sanitary commission in his present capacity in 1938.

Shaw's A.W.W.A. activities have included membership in the committees on joint administration of water and sewer facilities, public relations survey, and chairmanship of the Goodell Award committee. He has also written numerous papers on engineering subjects which were published in the JOURNAL and elsewhere.

Kentucky-Tennessee Section—Byron Elbert Payne, chief engineer and superintendent, Louisville Water Co., Louisville, Ky. Born in Hudson, N.Y., in 1902, he received his civil engineering degree from Rensselaer Polytechnic Inst. in 1925 and is a licensed professional engineer in New York and Kentucky.

Payne joined the Louisville utility in the capacity of draftsman upon leaving school, and was appointed assistant engineer in 1930. He became superintendent of pumping stations three years later and was principal assistant engineer from 1938 to 1941, when he assumed his present posts.

A past-president of the Louisville Engineers and Architects Club, Payne has also been chairman of his A.W.W.A. section and is a member of the committee on valves.

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Michigan Section—Raymond J. Faust, chief of the Section of Water Supply, Division of Engineering of the Michigan Dept. of Health, Lansing, Mich. Born in Millersburg, Pa., in 1901, Faust attended Pennsylvania State College, receiving the degree of B.S. in sanitary engineering in 1923. In 1935 he received the C.E. degree.

He joined the engineering staff of the health department in 1923, with duties ranging the whole field of public health engineering activities in the water and sewage fields. More recently his duties have been largely confined to water supply, with administrative and promotional activities predominating.

Faust is a registered professional engineer in Michigan and is active in professional and technical societies. He joined A.W.W.A. in 1938, when the Michigan Section was formed, and was secretary-treasurer of the section from 1944 until 1949.

Nebraska Section—Ray Case, general manager of the Board of Public Works in Beatrice, Neb. Case was born in Lyons, Kan., on Aug. 10, 1906, and obtained his education at Nebraska Wesleyan University and also the University of Nebraska, at Lincoln.

Upon completing his studies he entered the public utility field by joining the light and water department of Hastings, Neb. His next post, which he assumed in 1935, was that of business manager for the light and water department of Lincoln, Neb., and he performed that function for the next twelve years. In

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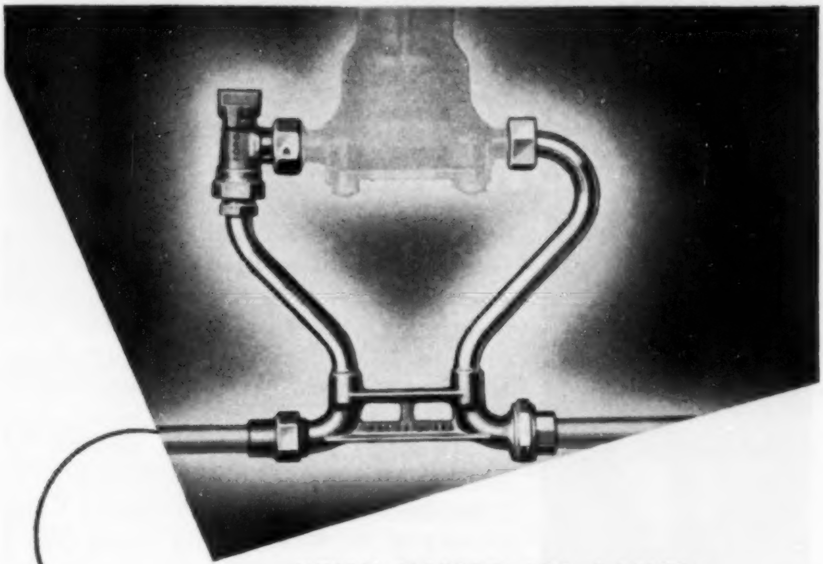

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1947 he was appointed to his present post in Beatrice, where his duties involve the management and operation of the light and water utilities.

Case is an active participant in the works of a number of professional and fraternal organizations and is currently chairman of the Utilities Section of the League of Nebraska Municipalities.

New England Section—Richard H. Ellis, engineer with the Factory Mutual Fire Insurance Companies, Boston. Born in Lawrence, Mass., in 1893, he attended Dartmouth College and received a B.S. degree in 1916 from the Thayer School of Civil Engineering. He is a registered professional engineer in Massachusetts.

Upon his graduation Ellis assumed the post of superintendent of public works in North Andover, Mass., and, except for a tour of duty in the Meteorological Corps during World War I, he served in this capacity until 1930. In that year he became water commissioner for Newton, Mass. Two years later he joined the Factory Mutual organization in his present capacity.

Ellis has been active in many professional societies and is a past president of N.E.W.W.A. He is a member of the committees on hydrants and water rates of A.W.W.A. and has been Secretary-Treasurer of his section for the past five years.

New Jersey Section—William G. Banks, division engineer of the Division of Water, Newark, N.J., Dept. of Public Works. A native of Newark, he was born there in 1889 and was graduated from Newark Technical School in 1908. He is a licensed professional engineer in New Jersey.

Upon leaving school Banks became junior engineer with the Central Railroad of New Jersey, leaving this post in 1913 to become engineer and superintendent for the Becker Construction Co. He joined the staff of the water division of Newark in 1914 as assistant engineer and was appointed to his present post in 1933.

Banks has been a member of A.W.W.A. since 1919, has been chairman of the New Jersey Section and received its Fuller Award in 1939. He is a member of the steel pipe committee.

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Bachrach

New York Section—Reeves Newsom, village manager of Scarsdale, N.Y. Born in Columbus, Ind., in 1893, he received a B.S. in civil engineering from Purdue Univ. in 1913 and did graduate work at Massachusetts Institute of Technology the following year. He then joined the Lynn, Mass., Dept. of Water Supply as resident engineer, becoming Superintendent and engineer and finally commissioner and chief engineer. In 1927 he joined the Community Water Service Co. to become chief engineer and general manager of operations for its 43 utilities in eleven states, with the title of executive vice-president and, later, president. He opened the consulting firm of Newsom and Aldrich in 1937 and accepted his present post at Scarsdale in 1944.

Newsom was president of A.W.W.A. in 1939 and has been chairman of the New York Section. He is now vice-chairman of the Water Works Practice Committee, chairman of the A.W.W.A. Pension System Administrative Committee, advisor to the Committee on Deep Wells and Deep Well Pumps, A.W.W.A. representative on the American Standards Assn. Committee on Specifications for Cast-Iron Pipe and Special Castings, and a member of the Financing Committee. This is his second term as director for the New York Section, the previous term having been from 1935 to 1938.

Pacific Northwest Section—Fred Merryfield, sanitary engineering professor at Oregon State College. A native of England, where he was born in Bury, Lancashire, in 1900, Merryfield was an R.A.F. pilot during World War I. He received his civil engineering degree from Oregon State College in 1923 and did construction engineering work with the Southern Pacific Railroad.

He joined the faculty of Oregon State as an instructor in 1928. The following year, while retaining this connection, he became assistant engineer for the North Carolina Dept. of Conservation and Natural Resources, and he completed the requirements for the M.Sc. degree in sanitary engineering at the University of North Carolina. During World War II he served as staff water supply officer of the Sixth Army in the Pacific. He has served on several state com-

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mittees on stream purification and has done much research on stream pollution and hydrology.

From 1936 until his election as director, Merryfield served as secretary-treasurer of the Pacific Northwest Section, and in 1944 he received its Fuller Award.

Bachrach

Pennsylvania Section—Elbert J. Taylor, chief, Bureau of Water, Dept. of Public Works, Philadelphia, Pa. Born in Weeping Water, Neb., in 1897, he attended the University of Cincinnati, from which he was graduated in 1923.

For the next two years Taylor worked in the Engineer Corps of the Pennsylvania Railroad, leaving to join the consulting firm of Morris Knowles in 1925. His association with that firm lasted for over 20 years, during which time he worked on the design and construction of filtration plants, distribution systems, sewage treatment plants, outfall sewers and other municipal engineering projects. In 1946 began his present association with the city of Philadelphia.

Taylor was a Trustee of the old Four States Section and last year was chairman of the new Pennsylvania Section.

Southeastern Section—N. M. deJarnette, public health engineer with the Georgia Dept. of Public Health at Atlanta. He is a native of the state, having been born at Roswell in 1899, and he received his B.S. degree from Oglethorpe University in 1920. After a brief interval with the Georgia Dept. of Public Health, deJarnette went out West to do graduate work in chemistry at the University of Colorado during 1922 and 1923. He also attended evening sessions at the Georgia School of Technology from 1930 to 1934, and is a registered professional engineer in that state. He returned to the Dept. of Public Health in 1935, as a public health engineer in the water and sewage fields. His activities in technical and professional organizations include membership in the Georgia Water and Sewage Assn., the Georgia Engineering Society, the Conference of State Sanitary Engineers, and the Georgia Public Health Assn.

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Manufacturer—William C. Sherwood, secretary of Hersey Mfg. Co., Boston, Mass. Born in Jersey City, N.J., in 1878, he received his education at business college and joined the Hersey organization as a clerk. He moved on to the job of salesman and was appointed assistant district manager in 1901, becoming manager of the New York territory a year later. In 1927 he was named assistant to the president, and, in 1930, secretary of the company.

Sherwood has been president of the Water and Sewage Works (or its predecessor, the Water Works) Manufacturers Assn., four times—in 1914, 1930, 1936 and 1946. He was elected as that organization's representative on the A.W.W.A. Board of Directors once previously, in 1946.

Raising a stink can sometimes be as difficult as getting rid of one. Thus we were interested, if not entirely flattered, when one of our leading consultants turned to us for the answer to such a stinker.

The Problem: How to create a bad odor in water at 190° to 200°F., being sold by a power plant for hot water heating purposes. Distribution is through a supposedly closed system, but system losses are very high. In view of the fact that the condensed steam involved provides a fine soft water, it is suspected that certain laundries, beauty shops and similar establishments are bleeding off their requirements, necessitating a large "make-up" at the power plant. The use of a dye is out, inasmuch as it would cause discoloration of fabrics, walls or anything else it came in contact with if the system sprung a leak.

Remembering that skunks would be unreliable, since they sometimes hibernate, and rebelling a little anyway at the thought of putrefying a product we've always tried to purify, we passed the buck to Matt Braidech, research director at the National Board of Fire Underwriters. His response:

> The suggested use of such organic sulfur-containing compounds as mercaptans and thiophenes, commonly employed in safety odorization of liquefied petroleum gases, will certainly meet with stiff objections from the fire safety authorities. The escape of such characteristic odors from condensate leaks would very definitely lead to other troubles, because of the false impression of the presence of fuel gas leaks.
>
> Substances like amyl valerate, skatole or even cadaverine might be suggested to meet the demand for "stink"—the former giving a strong sweaty odor of humid soapiness (similar to the "five o'clock crush of Bronxites" on the

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Lexington Avenue Subway), the other two also producing a very foul and putrid odor (analogous to ambrosial putrescence of septicemia).

Seriously, I feel that the highly pungent odor of our old friends, the chlorophenols, would be the best bet to meet all-around requirements—only small quantities would be required and they have good thermal stability and will carry over in cycles under boiler operating conditions. Perhaps the pentachlorphenol or pentachlorphenate, commonly employed for control of slime or biofouling in feedwater cooling ponds, would be particularly suitable. I might also suggest the use of methylamines and ethylamines, having odors of decayed fish, found in use for corrosion control in high-pressure steam lines. From an "acceptable" odor standpoint, the chlorophenols would meet my choice as the most suitable "water denial agents" in this case.

Needless to say, these suggestions give us a lot of raw material to work with, but if you have any other ideas on the subject, please waft them this way. Meanwhile, if your laundry or your wife comes home smelling like a dead fish, you'll know where the problem was.

Corrosion studies on buried pipe by the National Bureau of Standards have resulted in the formulation of a single empirical equation in which one constant represents the initial rate of corrosion for various metals and another represents the progress of corrosion with time for different soils. Details on the studies, which were begun in 1922, are contained in two recent articles by Denison and Romanoff in the Journal of Research of the Bureau (Vol. 44, pp. 47 and 259; 1950).

Fred Ohrt, who had won nomination for delegate to the Hawaii constitutional convention (April P&R, p. 40), was elected on March 21. Obtaining a clear majority from the Fifth District, he safely led the field of ten candidates, five of whom were seated. The territorial convention began its work on April 4 in anticipation of action by the U.S. Senate on its bid for statehood. The House has already approved the admission of Hawaii to the Union as a state.

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The sudden death on April 8 of Mrs. A. P. Black Sr. at the age of 77 came as a shock to her family, among whom are her son, A.W.W.A. President A. P. Black, and her grandson, Charles Black. Their many friends in the A.W.W.A. extend their sympathy to the Blacks on the occasion of their loss.

Edward S. Cole, retired president of the Pitometer Co. and A.W.W.A. Honorary Member, died on March 18 at his home in Upper Montclair, N.J., at the age of 78. A graduate in mechanical engineering of Cornell University in 1894, he invented his famous flow measuring instrument based on the Pitot tube only two years later, while working in his father's engineering firm. Another development based on the Pitometer was the Pitometer Log, an instrument for recording the speed of ships. He founded the Pitometer Co. in association with his father in 1904, and his son, E. Shaw Cole, is now chief engineer of the company.

Frank J. Egan, vice-president of James B. Clow and Sons, died suddenly and unexpectedly of a heart attack on April 10. He had been associated with the pipe industry for 30 years, having been with the National Cast Iron Pipe Co. (now a division of Clow) until 1926. In that year he joined the Clow organization as assistant manager of the foundry department, successively becoming manager and, in 1942, vice-president. He was a familiar figure in the water works and allied fields, whose passing was a shock to his many friends.

Ralph W. Reynolds, general superintendent of the West Palm Beach, Fla., Water Co., died on March 22 of a heart attack. He was 63 years old, and had been an A.W.W.A. Member since 1927. A native of Illinois, he helped organize the Florida Section and held the posts of trustee, chairman, and director from the section. In 1941 he received its Fuller Award.

A sales engineer is wanted to represent a well established manufacturer of distribution system equipment in New York and New Jersey. Qualifications include experience in selling or water utility operation. The position is permanent and offers salary plus bonus. Submit letter specifying educational background, experience, availability, salary desired, etc. If possible, enclose recent photograph and reference. Confidential. Address Box 550, American Water Works Assn.

Russell W. McIntosh has been appointed West Coast representative for Pittsburgh protective coatings, with headquarters in the Russ Bldg., San Francisco. The coatings are produced by the Pittsburgh Coke and Chemical Co.

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Spring is unquestionably here—here at least in Milwaukee and Los Angeles. Last week it was that we received a thoughtful penny postcard from one Milwaukee member asking us "Please change my address to . . . ." Of course, being young and turning fancy, he neglected to give us either his name or his old address, but, then, we understood. And this week, from Los Angeles, where love is still more virulent, came another card (an official government change of address form), properly enough addressed to us, but lacking any addresses, old or new, of the unidentified sender. Understanding still, we've taken appropriate action, but sumer is icumen in and we have an idea he's going to do more singeing than singing when his JOURNALS fail to reach him. Ah well, to understand in this case is to envy.

An unusual word on the fluoridation front comes in the form of a news release from the Washington Suburban Sanitary Commission, which, despite a recommendation from the Southern Maryland Dental Society, decided against instituting a program. Although they conceded that the plan had merit, the commissioners decided that fluoridation was still too experimental to be undertaken as a program for positive benefit.

(Continued on page 80)


Make a note of this!

Professional Services

Professional Services

(contd.)

Membership Changes

NEW MEMBERS

Applications received March 1 to 31, 1950

Adams, R. C., Asst. City Engr. & Supt. of Works, City Hall, Pitt St., Cornwall, Ont. (Jan. '50)

Allen, Frank R., Cons. Engr., Buxton & Allen, 902 Wallace Bldg., Little Rock, Ark. (Jan. '50) *MR*

Anderson, Clyde R., Supt., Water & Disposal, Park Rapids, Minn. (Jan. '50) *MP*

Bailey, Nat A., Tech. Director, Wright Chemical Corp., 627 W. Lake St., Chicago 6, Ill. (Jan. '50)

Barber, Charles L., Chemist, Shenango Valley Water Co., 100 Shenango Ave., Sharon, Pa. (Jan. '50) *P*

Billings, D. W., Dist. Mgr., Public Utility, Wisconsin Power & Light Co., Box 137, Ripon, Wis. (Jan. '50) *MR*

Boehm, Elmer H., Supt., Public Works, Village Hall, Bellwood, Ill. (Jan '50) *M*

Brocaw, W. C., Distr. Engr., Water Dept., Coffeyville, Kan. (Jan. '50)

Burhorst, Raymond F., Sr. Eng. Aide, Bureau of Water Supply, 2009 E. Lanvale St., Baltimore 13, Md. (Jr. M. Jan. '50) *M*

Case, Edmond W., City Water Supt., Newport, Ore. (Jan. '50)

Cathodic Servicing Co., T. M. Riseling, 1024 N. Olie St , Oklahoma City, Okla. (Assoc. M. Jan. '50)

Central Steel Tank Co., H. S. Ulrich, Box 1742, Wichita, Kan. (Assoc. M. Jan. '50)

Cherry, Donald Davis, Jr. Civ. Engr., Humble Oil & Refining Co., Civ. Eng. Div., Production Dept., Box 2180, Houston, Tex. (Jan. '50) *MP*

Cobb County Water System, Jack R. Davis, Supt., Box 146, Smyrna, Ga. (Corp. M. Jan. '50)

Collins, Lindsay Mathewson, Civ. Engr., Tighe & Bond, Cons., San & Hydr. Engrs., 189 High St., Holyoke, Mass. (Jan. '50)

Condit, John Milton, Div. Engr., R. W. Sparling, 1932—1st Ave., Seattle, Wash. (Jan. '50) *P*

Conrad, William F., Sales & Service Engr., Heldt-Monroe Co., Evansville, Ind. (Jan. '50)

Counts, Harlan B., Hydr. Engr., U.S. Geological Survey, Ground Water Branch, 515 E. 2nd St., Little Rock, Ark. (Jan. '50)

Cover, Walter E., Asst. Supt., Water Dept., 509—2nd St., N.E., Little Falls, Minn. (Jan. '50) *MP*

Craftsmen Decorating Service, Kenneth P. Sullivan, 7654 S. Park Ave., Chicago 19, Ill. (Assoc. M. Jan. '50)

David, Thomas C., Partner, Pan American Engrs., 1418—3rd St., Alexandria, La. (Jan. '50) *PR*

Davis, David Goldberg, Pres. & Chief Engr., Ball Valve Co., 9815 Wilshire Blvd., Los Angeles, Calif. (Jan. '50).

Davis, Jack R., *see* Cobb County Water System

Deibele, D. S., Supt., Munic. Utilities, Garrett, Ind. (Jan. '50) *MPR*

Demers, R. E., City Supt., Water Works & Highways, City Hall, Levis, Que. (Jan. '50)

Deniger, Jean F., Sales Engr., Associated Chemical Co. of Canada, Ltd., 432 Ontario St., W., Montreal, Que. (Jan. '50)

Dooley, H. L., *see* Gainesville, City of

Euler, Louis Mohr, Water Supply Engr., Washington Suburban San. Com., Hyattsville, Md. (Jan. '50) *P*

Evans, Leroy J., Eastern Mgr., Mueller Co., 1322 Empire State Bldg., New York 1, N.Y. (Jan. '50)

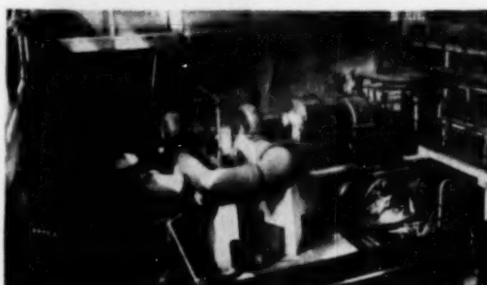
Evans, William T., Vice-Pres. & Treas., Shenango Valley Water Co., Box 542, Sharon, Pa. (Jan. '50) *M*

(*Continued on page 34*)

Philadelphia's first pumping engine, installed in the year 1800 (not a De Laval).

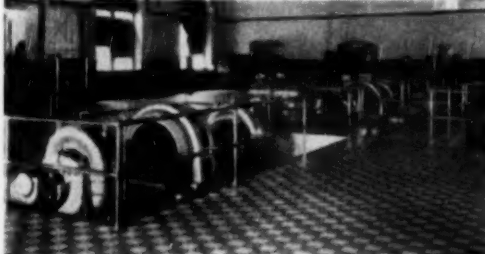
1907

THE FIRST CENTRIFUGAL WATERWORKS PUMP IN PHILADELPHIA AND ONE OF THE VERY FIRST IN THE ENTIRE NATION.
The city of Philadelphia was one of the first to replace the ponderous pumping engines of the nineteenth century with compact, highly efficient turbine-driven centrifugal pumps. The first of the centrifugal units to be used by the city of Philadelphia was a De Laval 2½ mgd turbine-driven unit installed at the Torresdale Station in the year 1907.



QUEEN LANE PUMPING STATION
In the year 1919 the City of Philadelphia broke all records for pumping capacity by equipping the Queen Lane Pumping Station with four De Laval turbine-driven units each having a capacity of 40 mgd against 279′ head.

ROXBORO BOOSTER STATION
One De Laval 17 mgd and two De Laval 20 mgd motor-driven pumps were used in this station.



SHAWMONT PUMPING STATION
These two De Laval 2,095 hp motor-driven, centrifugal pumps have a capacity of 25 mgd each against 405′ head.

BELMONT PUMPING STATION
Three De Laval motor-driven centrifugal pumps designed to deliver 25 mgd against 334′ head.

(*Continued from page 30*)

Farrell, Justin Edward, Sr. Asst. Engr., Constr. Div., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Jan. '50) *M*

Gainesville, City of, H. L. Dooley, Water Supt., City Hall, Gainesville, Ga. (Corp. M. Jan. '50)

Garland, William T., Asst. Mgr., Consolidated Western Steel Corp., Box 790, Phoenix, Ariz. (Jan. '50) *P*

Garvey, Kenneth E., Supt., Water Div., Dept. of Public Works, 2 City Hall, Battle Creek, Mich. (Jan. '50) *MPR*

General Reduction Co., C. E. Glasser, Pres., 330 S. Dearborn St., Chicago 6, Ill. (Assoc. M. Jan. '50)

Gilbert, J. J., *see* Link-Belt Co.

Glasser, C. E., *see* General Reduction Co.

Goulding, Randolph, Asst. Engr., Wiedeman & Singleton, 930 Williams Mill Rd., N.E., Atlanta, Ga. (Jan. '50)

Grenier, Francois, Town Engr. & Mgr., Malartic, Que. (Jan. '50)

Griffith Water Works, William M. Kussmaul, Supt., Town Hall, 109 N. Broad St., Griffith, Ind. (Corp. M. Jan. '50)

Hammergren, Evert, Supt., King County Water Dist. No. 80, 2110 E. Main, Auburn, Wash. (Jan. '50) *M*

Hammerli, Walter, *see* Winthrop-Stearns, Inc.

Harmon, Frank, Supt., Water Works, Delta, Ohio (Jan. '50)

Hespeler, Town of, Water Works Com., Ed Meyer, Water Works Supt., Hespeler, Ont. (Jan. '50) *M*

Hicks, T. J., Partner, Culligan Soft Water Service, Box 1259, Fort Lauderdale, Fla. (Jan. '50) *MP*

Holtje, Ralph Henry, Chief, Stream Pollution Section, State Board of Health, 1330 W. Michigan St., Indianapolis, Ind. (Jan. '50) *R*

Hopkins, Edward D., Water Supt., 4 E. Kennewick Ave., Kennewick, Wash. (Jan. '50) *M*

Howard, Nelson, Supt., Water Works, Water & Light Plant, 415 W. Broad St., Newcastle, Ind. (Jan. '50)

Howell, Robert, Water & Sewage Plant Foreman, Post Engr. Div., Ravenna Arsenal, Dept. of the Army, Apco, Ohio (Jan. '50) *M*

Huston, George J., Salesman, Water Filtration Div., Bowser, Inc., 420 Lexington Ave., New York 17, N.Y. (Jan. '50) *P*

Iverson, Harry G., Supt., Light & Power, Sumas, Wash. (Jan. '50)

Kerr, Frank H., *see* Prescott Public Utilities Com.

Knoop, Frederick R., Jr., Designer, Whitman, Requardt & Assoc., 1304 St. Paul St., Baltimore, Md. (Jan. '50) *PR*

Kussmaul, William M., *see* Griffith Water Works

Lang, Jerome C., Culligan Soft Water Service, Beverly Hills Branch, 1611 S. La Cienega Blvd., Los Angeles 35, Calif. (Jan. '50)

Link-Belt Co., J. J. Gilbert, 2045 W. Hunting Park Ave., Philadelphia 40, Pa. (Assoc. M. Jan. '50)

Masson, Donnell S., System Maint. Engr., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Jan. '50)

McCosh, Harry P., Water Distr. Foreman, Water Dept., Abilene, Kan. (Jan. '50)

McDermitt, Pat E., Com. of Finance & Member of Water Board, St. Paul, Minn. (Jan. '50)

McKimmon, William S., Sr. San. Engr., State Board of Health, Raleigh, N.C. (Jan. '50)

Melson, Marvin A., Supt., Water Works System, Eagle Pass, Tex. (Jan. '50) *MP*

Merriman, George Joseph, Water Operator, Lake Tamarack Assn., Stockholm, N.J. (Jan. '50) *MP*

Meyer, Ed, *see* Hespeler, Town of

Mitchell, Hobart, Mgr., Culligan Soft Water Service, Box 648, Lubbock, Tex. (Jan. '50) *MP*

Mood, Eric William, Instructor in Public Health, Yale Univ., Dept. of Public Health, 310 Cedar St., New Haven, Conn. (Jan. '50) *P*

Murdoch, Gilbert G., Civ. & Cons. Engr., Corner Leinster & Carmarthen Sts., Saint John, N.B. (Jan. '50)

Myers, Charles A., Partner, Pan American Engrs., 1418—3rd St., Alexandria, La. (Jan. '50) *P*

Nippler, Robert W., Student, Georgia Inst. of Technology, Atlanta, Ga. (Jr. M. Jan. '50)

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(Continued from page 34)

O'Connor, Daniel J., Registrar, Bureau of Water, 1541 S. 28th St., Philadelphia 46, Pa. (Jan. '50)

Prescott Public Utilities Com., Frank H. Kerr, Supt., Prescott, Ont. (Corp. M. Jan. '50)

Ranger, City of, Jesse W. White, Water Dept., Ranger, Tex. (Corp. M. Jan. '50) *MP*

Ranney, Leo, Professional Engr., Box 67, Morro Bay, Calif. (Jan. '50) *R*

Rasmussen, Charles W., Mgr., Ajo Improvement Co., 207 Taladro, Ajo, Ariz. (Jan. '50) *M*

Rehtmeyer, Robert T., Sales Engr., Ingersoll Rand Co., 1460 E. 4th St., Los Angeles, Calif. (Jan. '50) *MP*

Rickmeyer, Henry W. C., *see* West Hempstead-Hempstead Gardens Water Dist.

Riseling, T. M., *see* Cathodic Servicing Co.

Ritchie, Wells, Editor, *Civic Administration,* Maclean-Hunter Publishing Co., Ltd., 481 University Ave., Toronto 2, Ont. (Jan. '50)

Schooler, Ben H., Director-Secy., Mt. View Edgewood Water Co., Route 1, Box 95, Puyallup, Wash. (Jan. '50) *M*

Scott, Robert B., Dist. Mgr., Worthington Pump & Machinery Corp., 2428 University Ave., St. Paul 5, Minn. (Jan. '50) *R*

Self, Joseph B., Jr., Chief Engr., Joplin Water Works Co., 2102 Picher Ave., Joplin, Mo. (Jan. '50)

Smith, Sanford A., Well Field Supervisor, Water Supply, Wichita, Kan. (Jan. '50) *MR*

Stephen, G. W., Tech. Service Dept., Canada Colors & Chemicals, Ltd., 1090 King St., W., Toronto, Ont. (Jan. '50)

Stowe, Charles R., Mgr., Products Div., Carter Products Corp., 10225 Meech Ave., Cleveland 5, Ohio (Jan. '50)

Sullivan, Kenneth P., *see* Craftsmen Decorating Service

Tait, Donald B., Geologist, U.S. Geological Survey, 515 E. 2nd St., Little Rock, Ark. (Jan. '50)

Tart, Alfred N., Sales Engr. & Pres., Tart-Ide Corp., 13118 Wayzata Blvd., Route 10, Minneapolis 16, Minn. (Jan. '50) *PR*

Taylor Foundry Co., Lloyd J. Taylor, Box 213, Wichita Falls, Tex. (Assoc. M. Jan. '50)

Taylor, Lloyd J., *see* Taylor Foundry Co.

Taylor, William Harmon, Jr., Engr., Water Dept., 319 City Hall, Pasadena, Calif. (Jan. '50)

Tuckett, Norman L. R., Jr., San. Engr., Broward County Health Dept., 501 S. Andrews, Fort Lauderdale, Fla. (Jan. '50)

Ulrich, H. S., *see* Central Steel Tank Co.

Wachs, E. H., Co., Edward H. Wachs, Secy., 1525 N. Dayton St., Chicago 22, Ill. (Assoc. M. Jan. '50)

Wachs, Edward H., *see* Wachs, E. H., Co.

Walker, George L., Export Mgr., Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia, Pa. (Jan. '50)

Walker, Robert E., Design Engr., Smith & Gillespie, Engrs., Box 1048, Jacksonville, Fla. (Jan. '50)

Wendel, Leon H., Cons. Engr., 33 Morrow Ave., Lockport, N.Y. (Jan. '50) *MPR*

West Hempstead-Hempstead Gardens Water Dist., Henry W. C. Rickmeyer, Supt., 575 Birch St., West Hempstead, N.Y. (Corp. M. Jan. '50)

White, Jesse W., *see* Ranger, City of

Whitworth, George F., Civ. Engr., National Park Service, 307 Federal Bldg., Omaha, Neb. (Jan. '50)

Wiedeman, Theodore W., Asst. Engr., Wiedeman & Singleton, 934 Williams Mill Rd., N.E., Atlanta, Ga. (Jan. '50)

Williams, Paul K., Engr. in Charge of Water Works & Sewer Constr., State Water Conservation Board, Helena, Mont. (Jan. '50)

Williamson, Arthur E., Director, Div. of Munic. Eng., State Dept. of Health, Bismarck, N.D. (Jan. '50)

Winthrop-Stearns, Inc., Walter Hammerli, Chief Engr., 33 Riverside Ave., Rensselaer, N.Y. (Corp. M. Jan. '50) *MP*

REINSTATEMENTS

Beatty, Melvin, 17150 Maumee Ave., Grosse Pointe 30, Mich. (July '47)

Carl, Charles Elard, Director, Div. of San. Eng., State Dept. of Health, Pierre, S.D. (Jan. '43)

Cox, Rupert L., 3417 Kensington Ave., Richmond 21, Va. (Oct. '47) *MP*

Kachorsky, Michael S., Supt., Public Works, 101 S. Main St., Manville, N.J. (June '39) *MPR*

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Max, John, Supt., Water Purif. Plant, 1105 W. Cross St., Ypsilanti, Mich. (July '46)

Tomek, Arthur O., San. Engr., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Oct. '35) *MPR*

Williams, G. D., Cons. Engr., Assoc. of Julien Montgomery, 602 West Ave., Austin, Tex. (Oct. '48) *P*

LOSSES

Deaths

Cole, Edward S., 133 Bellevue Ave., Upper Montclair, N.J. (June '02) *Honorary M. '43. M*

Hess, Irving C., Div. Engr., California Water & Telephone Co., Box I, National City, Calif. (Jan. '41)

Read, A. W., R.F.D. 7, Bangor, Me. (July '35)

Reynolds, Ralph W., Gen. Supt., West Palm Beach Water Co., Box 1311, West Palm Beach, Fla. (Nov. '26) *Director '40–42. Fuller Award '41. MPR*

Resignations

Dixon, James I., Supt., Water Dept., 401 Benton St., Santa Clara, Calif. (May '26)

Reed, Allen M., Chemist, Electric Auto-Lite Co., Lockland, Ohio (Apr. '44) *P*

CHANGES IN ADDRESS

Changes received between March 5 and April 5, 1950

Alexander, Aleck, 1602 Bannock St., Boise, Idaho (July '48)

Anderson, E. L., Dist. Mgr., California Water Service Co., Stockton, Calif. (Oct. '44)

Bryant Water Tank Service, E. H. Bryant, Mgr., Gen. Delivery, Lutz, Fla. (Assoc. M. July '46)

Builders-Providence, Inc., Charles G. Richardson, Vice-Pres., 345 Harris Ave., Providence 1, R.I. (Assoc. M. June '01)

Daniels, Roy D., Chemist, Water Works Dept., 2107—16th St., Parkersburg, W.Va. (Jan. '47) *P*

Davis, Don C., City Engr., City Hall, Banning, Calif. (Jan. '41) *M*

Delaney, John J., Pres., Marquette Heights Utility Co., 100–102 Joliet Rd., Marquette Heights, Pekin, Ill. (Jan. '49)

Deutsch, Fred W., Mgr., Standards & Eng. Products, Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. (Apr. '45) *P*

Duncan, Malcolm E., Sales Engr., Johns-Manville Sales Corp., 1701 E. 7th St., Tulsa 4, Okla. (Jan. '44) *M*

Evans, Charles A., Resident San. Engr., Tennessee Valley Authority, 640 New Sprankle Bldg., Knoxville, Tenn. (July '48)

Feagan, George H., 603 E. 28th St., Bryan, Tex. (Jan. '48)

Forbes, M. C., Aquatrol, Inc., Box 12233, Houston 17, Tex. (Jan. '48)

Fowler, James D., Koch & Fowler, 3900 Lemmon Ave., Dallas, Tex. (July '35)

Gahr, William N., Director, Div. of Sanitation, State Dept. of Public Health, 720 Boston Bldg., Denver 2, Colo. (Jan. '46)

Gibbons, Mortimer M., Puerto Rico Aqueduct & Sewer Authority, Box 2832, San Juan, Puerto Rico (Nov. '22)

Gomez Laurens, Gilberto, 907 E. Huron St., Ann Arbor, Mich. (Jr. M. Oct. '49)

Hardman, Robert L., 18 Columbia Ave., Dumont, N.J. (Jan. '47)

Hartley, John R., Asst. Sales Mgr., Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. (Apr. '43) *MPR*

Heider, Robert W., Asst. Director, Div. of San Eng., State Board of Health, 1330 W. Michigan St., Indianapolis 7, Ind. (July '37) *PR*

Hennings, John P., Portland Water Dist., R.F.D. 1, Cumberland Center, Me. (Oct. '41) *M*

Hodges, S. M., Purif. Engr., Water Dept., 205 Kempsville Rd., Norfolk, Va. (Oct. '43) *P*

Huntress, Charles O., 4127 W. 73rd St., Mission, Kan. (Apr. '40) *MPR*

Jones, T. E., Supt., Water Dept., Gatlinburg, Tenn. (Jan. '40) *M*

Kawata, Kazuyoshi, 2404 E. 22nd St., Minneapolis 6, Minn. (Jr. M. Jan. '50)

Kendrick, Edward J., 30 Fairview St., Huntington, N.Y. (Apr. '46)

Kreinheder, Jerome C., 171 Laurel St., Buffalo 8, N.Y. (Jan. '46) *MPR*

(*Continued on page 40*)

For WATER and SEWAGE

specify

GENERAL CHEMICAL "ALUM"

WATER experts agree—"alum" is the preferred coagulant for the removal of turbidity, color and other impurities in the water . . . *and General Chemical Aluminum Sulfate is the preferred "alum."*

SEWAGE experts agree—"alum" is preferred for the clarification of sewage because it flocs out the suspended solids and colloids . . . *and General Chemical Aluminum Sulfate is the preferred "alum."*

THE REASON: For over 50 years, General Chemical Aluminum Sulfate has been processed to meet the most rigid chemical and physical specifications. Its quality, uniformity and reliability are preferred by most cities the nation over. For your operations, *specify General Chemical "Alum."*

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In Wisconsin: General Chemical Company, Inc., Milwaukee, Wis.

In Canada: The Nichols Chemical Company, Limited • Montreal • Toronto • Vancouver

(Continued from page 38)

Lang, William Harvey, Box 121, Linden, N.J. (Oct. '42) *PR*

Lobb, John Everett, Director, Div. of General Sanitation, State Dept. of Health, Bismarck, N.D. (July '43) *P*

Lundy, Thomas Emmett, Design Engr., Koch & Fowler, 3900 Lemmon Ave., Dallas, Tex. (Oct. '47) *MPR*

Moore, Herbert, Hydr. & San. Engr., 1330 N. Franklin Pl., Milwaukee 2, Wis. (July '28) *MPR*

Moore, Russell B., Cons. Engr., 2266 N. Meridian St., Indianapolis 8, Ind. (Jan. '28) *P*

Naylor, George Wilson, Mgr., Vandergrift Water Co., 311 N. 2nd St., Apollo, Pa. (July '35) *MP*

Ohio Dept. of Natural Resources, Div. of Water, C. V. Youngquist, Chief, Ohio State Fairgrounds, Columbus 3, Ohio (Corp. M. Oct. '45) *R*

Omega Machine Co., Div. of Builders Iron Foundry, Roland J. Leveque, Sales Mgr., 345 Harris Ave., Providence 1, R.I. (Assoc. M. Jan. '30)

Papineau, Marcel, Metropolitan Com., 10 W. St. James St., Montreal, Que. (Apr. '49)

Papp, Remig Anthony G., Civ. Engr., Box 62, Princeton Junction, N.J. (Oct. '49) *MPR*

Poland, Joseph F., Dist. Geologist, U.S. Geological Survey, 2520 Marconi Ave., Sacramento 15, Calif. (Jan. '47) *R*

Porter, Earl, Civ. Engr., Porter, Barry & Switzer, 545 Lafayette St., Baton Rouge, La. (Jan. '49)

Proportioneers, Inc., H. E. Hollberg, Vice-Pres., 345 Harris Ave., Providence 1, R.I. (Assoc. M. Apr. '39)

Pullen, P. T., Field Engr., Electro Rust-Proofing Corp., 2304 Greswell St., Shreveport, La. (Oct. '45)

Randlett, Fred Morse, Vice-Pres. & Gen. Mgr., Robert W. Hunt Co., Union League Club, Chicago, Ill. (June '20) *Trustee '25–27.*

Richardson, Charles G., Vice-Pres., Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. (July '20)

Ritter, A. B., 936 Broadway, New Orleans 18, La. (Oct. '48)

Rogers, Milford E., Project Engr., Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. (Jan. '45) *P*

Saville, Caleb Mills, Cons. Engr., Metropolitan Dist. Com., 115 Broad St., Hartford 5, Conn. (Mar. '16) *MP*

Sillers, Russell Verne, Water Plant Supt., Water Dept., 613—9th St., Huntsville, Tex. (Jan. '47)

Slattery, Patrick J., Sherbrooke, W., Que. (July '48)

Smith, Arnold R., 35–33—83rd St., Jackson Heights, N.Y. (July '48)

Smith, Marlo E., Capt., 456 Cloverleaf Ave., San Antonio, Tex. (Jan. '49)

Smith, Norman F., Vice-Pres., International Water Co., Apdo. Aereo No. 1519, Cali, Colombia (July '38)

Soffe, Benjamin F., Box 389, Tucson, Ariz. (Apr. '44) *P*

Sohle, Frederick Victor, Sales Mgr., R. D. Wood Co., 500 Santa Fe Bldg., 1122 Jackson St., Dallas 2, Tex. (Oct. '42)

Streander, Philip B., Cons. San. Engr., 683 Atlantic Ave., Boston 11, Mass. (Dec. '23) *MP*

Sturtevant, F. L., Sales Repr., Wintroath Pump Co., Box 1266, Lancaster, Calif. (Oct. '46)

Thomas, Harold E., 73 S. Bayview Ave., Amityville, N.Y. (Jan. '49)

Thompson, Ralph F., Gen. Delivery, College Station, Tex. (Jan. '48) *PR*

Troy Bureau of Water, William Luby, Comr. of Public Works, 3118—7th Ave., Troy, N.Y. (Munic. Sv. Sub. May '24)

Wendell, Raymond T., American Water Works Service Co., 928 N. 3rd St., Harrisburg, Pa. (Apr. '44) *M*

Winder, Norman G., 3212 Hall St., Dallas 4, Tex. (Oct. '39)

Correspondence

Red Hot

To the Editor:

I note your P.S. to the review of Falkovski's book *Our Water Supply in Russia* by Danilevski [Feb. JOURNAL p. 207], and am constrained to ask, along the same lines, why no mention is made by the author of that brilliant and dynamic exponent of Soviet water works practice, Dr. Alexei Kravchenko.

It was the writer's privilege at our A.W.W.A. Section convention in Bay City (1947) to hear this gentleman deliver a forceful yet learned discussion on "Water Supply in Russia" which had his two hundred odd listeners completely enthralled. His presentation of the subject is still discussed wherever water works men gather.

His paper was certainly a notable contribution not only to water works literature but to history and politics as well.

I understand Dr. Hulbert has a copy of his paper in case you would care to examine it—perhaps you have it in your files.

Let's be fair!

F. W. DuBois

DuBois-Webb Co., Inc.
2832 E. Grand Blvd.
Detroit 11, Mich.; Mar. 13, 1950

In apologizing to Comrade DuBois for our traitorous deviation from the party line, we explain that, like him, we remembered "Kravchenko" as the name of our illustrious cohort "Krazchenko," and, having an understandable aversion for the former name, thus, pointedly ignored it. Confessing, however, that our error was both bourgeois and imperialistic, we have prepared ourself for purge.

Meanwhile, before **you** *do anything rash, you should be reminded that Comrade Krazchenko did give a most convincing speech at the 1947 Michigan Section meeting—so convincing in fact that a number of the "completely enthralled" listeners, including A.W.W.A.'s official representative at the meeting, walked out on his propaganda long before he dropped his accent and disguise and turned out to be one Roberts Hulbert, member in good standing and excellent humor. Having missed the original performance and almost forgotten its mention (Nov. 1947 P&R, p. 74), we received the intended jolt from our straight-faced friend's last paragraph.*—ED.

More Heirs Apparent

To the Editor:

Have just noticed your "Blood is thicker than water" item in the JOURNAL (Feb. P&R p. 18). Check your membership list and you will find that Theo. D. Faulks (Apr. '37) and yours truly, J. Harris Faulks (Oct. '35), could join the above-mentioned group.

J. HARRIS FAULKS

Maplewood, N.J.; Mar. 6, 1950

To the Editor:

I was much interested in the "Blood is thicker than water" in the February number of the JOURNAL. While I do not know all of the fathers, I suppose all are living. It occurred to me that there are many combinations in which the father may have passed away. I thought of several which might be considered if you thought it worth while to continue with this feature

(*Continued on page 44*)


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(Continued from page 42)

. . . . I am enclosing a list [see p. 80, this issue] which you may use in any way you see fit. . . .

Edward Bartow
Dept. of Chemistry & Chem. Eng.
State Univ. of Iowa, Iowa City
Iowa; March 24, 1950

As the data roll in, we wonder why none of our 35 Browns, 41 Joneses, 51 Johnsons and 75 Smiths will acknowledge any relationship.—Ed.

T + 150 = F

To the Editor:

Just by way of proving to you that I am among those who do read the Journal, I should like to point out that in the February 1950 issue there is an article on text page 107 by Thomas M. Niles of Greeley & Hansen's office.

Under "Section Meeting Reports," and in the report for the Chesapeake Section on P&R page 58, it is noted that F. M. Niles, of Greeley & Hansen, presented his paper at that meeting.

I thought I did pretty well to be able to read about 150 pages and still note that the "F.M." are not Mr. Niles' correct initials.

Carl N. Brown
U.S. Pipe & Foundry Co.
122 S. Michigan Ave.
Chicago 3, Ill.; Mar. 6, 1950

Upon cover-to-cover reader Brown, we confer the esteemed Order of the Peripatetic Proofreader, reserved for keeneyes in other walks of life than editing. But our blush at having misinitialed Thomas with an "F" is completely lost in the flush of pleasure at finding so thorough a reader. We'll watch warily from now on, but won't be too upset if other readers do our editing up as Brown.—Ed.

Condensation in Hot Water

To the Editor:

Admittedly, the organization of the Journal—I mean the way the contents are offered to the readers—is chiefly an American problem, and though being a member of the Association since 1927, I do not consider I am qualified (being a non-American member) to discuss the modernization of the Journal, as long as it concerns Willing Water, the Great Gildersleeve, picture cover, text and advertising cocktails; nor do I attempt to resist the pleasure of reading those witty and inimitable editorial comments. I suppose all these changes reflect some of the actual aspects of the profession in the United States, and I have no objection anyway to taking our burden in a lighter way.

Even if the name of "abstracts" is changed to "condensation," I can con-

(Continued on page 46)

(*Continued from page 44*)

sider it is a pure question of vocabulary.

But when the abstracts begin to be curtailed, and are so lightened in the January issue as to vanish completely, I feel the JOURNAL takes a turn about which you might be interested to hear a comment from abroad.

Thanks to the abstracts, I have used extensively the JOURNAL for many years as a very precious and universal key to world-wide water works literature. Nothing of value could be missed. On that line, it was unique. Now I find only in it a few American papers, condensation from a few others (all American in the February issue) and a lot of American advertising. All this is useful and interesting, but it makes a great difference: the JOURNAL is now a purely national magazine, as many others are, but it has lost its international character, together with its value of *general* information. You will excuse me if I consider this is a very serious restriction.

R. MICHAU
Controleur des Services Techniques et Industriels
98, Quai de la Rapee
Paris 12, France; Mar. 7, 1950

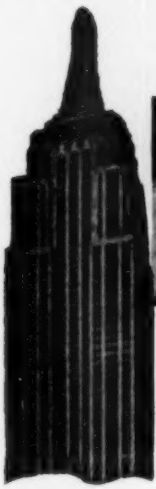
To the Editor:

For somewhat more than a year I have not had occasion to use the JOURNAL actively in my work and merely filed my copies as they were received. Recently, however, I undertook to collect information which required a search of the JOURNAL and I was surprised to find that a marked change had been instituted in the manner of handling the abstract section.

The abstract section in the JOURNAL has always been a very good one because of the completeness of the individual abstracts and the fact that the annual volume carried an index to it. It seems to me that the new method of handling this section is a step back-

(*Continued on page 48*)

Many are the reasons why Smith hydrants are used by America's leading cities!



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New York — Philadelphia — Washington — Baltimore — St. Louis — Providence and scores of other cities throughout the nation use SMITH hydrants — and not without good reason. A few of these reasons can easily be seen upon inspection of the hydrant section shown at the left.

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31

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(Continued from page 46)

ward although you may have excellent reasons for the new procedure. The principal disadvantage is the lack of an index, but another was discovered in examining the bound library copy for 1949. This volume contained no abstracts at all because it was not noticed that the abstracts are now interlarded with the advertising pages.

I think it would be highly desirable to restore the abstract section to its former status and consecutive pagination with the rest of the volume. The index should also be restored to simplify literature searches.

RICHARD D. HOAK
Senior Fellow
Mellon Inst. of Industrial Research
Univ. of Pittsburgh
Pittsburgh, Pa.; Mar. 16, 1950

To the Editor:

I very much appreciate the way your journal is edited and its habit of providing space for constructive criticism as regards the presentation of the material to the reader. I feel sure that your journal must be considered amongst those in the first ranks of its kind.

Nevertheless I take the liberty of expressing my opinion—which is actually shared by a number of other readers in this country—as regards the new method of presenting the abstracts adopted by you since January 1949. The abstracts as provided up to that date were certainly a very important feature of the JOURNAL, giving us very good hints as to what was going on in the field of water treatment throughout the world. We would very much like to see the JOURNAL returning to the old way of presenting the abstracts and of placing them in the textual part of the JOURNAL instead of printing them amongst the advertisements.

We noted with regret that the subject of Condensation did not figure in

(Continued on page 50)

(*Continued from page 48*)

the index of the JOURNAL's 1949 edition.

N. AYALON

N. Ayalon & J. Etzioni, Chem. Engrs.
51 Kingsway
Haifa, Israel; Mar. 16, 1950

To the Editor:

I am glad to note from p. 22 of the Correspondence part of the February JOURNAL that you may be interested in knowing the way that different readers feel about abstracts.

My personal opinion is that the JOURNAL has lost a very essential part of its value when it reduced abstracts to the present low level.

There is merit in printing abstracts—or condensations, if you prefer that word—with advertisements on their back; or some readers may consider the ads as the front part. There is no excuse for practically eliminating them; mainly when a lot of pages continue to be filled with the more or less humorous Percolation and Runoff.

I have read the JOURNAL for fifteen years, and have subscribed for it, as an Association member, a few months ago. I will certainly drop my membership and subscription if the poor editorial policy of the past few months is not reversed.

F. D. PRAGER

Puromat Co.
30 N. La Salle St.
Chicago 2, Ill.; Mar. 25, 1950

Keep this up and we'll get the idea that the Condensation section is not entirely satisfactory. Seriously, though, we are making an effort to increase the number of abstracts printed and we shall provide some sort of index to them at the end of this year. The absence and Americanism, which M. Michau noted, were, of course, temporary troubles that will iron themselves out. The change of location, to which Messrs. Hoak and Ayalon object, is a more serious problem, since restoring the section to the text portion would involve either publication of approximately 16 more pages per month at no little expense or reduction of the technical articles by that amount. As noted above, the quantitative difficulties cited by Mr. Prager are being solved now; and for his satisfaction, we should point out that by the original relocation, P&R's space was cut in about half.

For the balance of this year at least, we shall have to continue the Condensation section in its present location increasing its space allotment as much as conditions permit, but we shall be giving serious consideration to making further changes in 1951. In that consideration, of course, we must take into account also the desires of a number of other members who prefer to have their abstracts printed on one side of a page only, because it permits them to clip and file them individually in their personal repositories of water works knowledge.

To help us devise a universally satisfactory solution, these comments and those of as-yet-unheard-from readers and users of the abstracts will be most valuable. Any solution, however, must be based on an understanding that the 1949 change was made for economical reasons and not on anyone's whim.—ED.

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issued dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene* (*Great Britain*); *C.A.—Chemical Abstracts; I.M.—Institute of Metals* (*Great Britain*); *P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.R.—Water Pollution Research* (*Great Britain*).

WATER METERS

Water Meters for Domestic and Small Trade Supplies. ANON. Wtr. & Wtr. Eng. (Gt. Br.) **51**:506 (Nov. '48). Meter should: [1] accurately measure all water at max. and min. flow rates; [2] cause min. restriction of flow; [3] not be liable to stoppage; [4] resist corrosion by waters of normal chem. compn.; [5] be small in bulk; [6] be easy to fix; [7] be quiet at all flows; [8] be easy to read; [9] be moderate in cost; [10] operate satisfactorily and accurately for 3–5 yr. without repairs; and [11] have useful life of 20–25 yr. with low maint. costs. Meters at present available can be grouped as [1] positive or semipositive displacement types which measure vol. by counting number of times known quant. of water displaced from inlet to outlet ports of meter; and [2] inferential type, which measures veloc. by means of fan, rotor or turbine. Positive meters usually of reciprocating piston type. When in good order they are most accurate meter available. Their bulk, relative to capac., much greater than for other types. Initial cost about twice that of inferential or rotary-piston meter. Rotary- or oscillating-piston type classed as semipositive meter, including nutating-disc meter. Latter not normally in use in Great Britain. Accuracy of rotary-piston meter depends largely on clearances between piston and working chamber. Possible for meter to stop in such position that water can flow through without being registered. Normal accuracy tolerance is 2% over wide range. Many ½″ meters will commence registration in region of 1 gph. (Imp.). Semipositive meter comparatively small in size and first cost low. Piston usually of ebonite or similar material, for which water lubricant. Inferential meters include single-jet vane or fan type, multiple-jet vane or fan type, helical-rotor type and turbine type. Single- and multiple-jet vane or fan type mfd. mainly in smaller sizes up to about 2″. Helical-rotor meters used for larger sizes. Turbine type meters, in which water passes down center and out tangentially from turbine blades, not often used. Vane type meters used in large quant. for measuring domestic and small trade supplies. Inferential meters can be expected to require more frequent attention than rotary-piston meters if initial accuracy to be maintd. Selection of suitable size of meter depends on knowledge of max. and min. flows. Too large meter means greater initial outlay and loss in registration in low flows; too small meter will cost more in maint. and may cause severe restriction of flow. Somewhere during declining performance of meter is point at which it should be removed and restored to original condition. This period will vary with type and make. When new meter replaces stopped meter, customer likely to complain of increased bill. Repair mechanic should become familiar with meters by short period of training at mfr.'s works, visits from mfr.'s service engr. and study of maint. book supplied by mfr. Considerable latitude in choice of test equip. It

(*Continued on page 54*)

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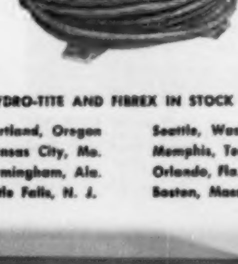

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may vary from any tank with line marked inside to show certain quant. to elaborate app. of calibrated tanks with glass gages and and scales, manometers for indicating rate of flow and pressure loss, facilities for low-flow tests and provision for testing 6–12 meters at one time. Record card for each meter should provide name of mfr., size, type, serial number, date purchased and price, date first installed, location, date removed for repair, reading and conditioning, repair details and maint. costs. Before carrying out tests, meter should be well flushed to remove all air. This flow of water should be curtailed when first pointer of counter at convenient place for commencing test. Some authorities would consider accuracy tolerance of 3% good enough for repaired meter.—*H. E. Babbitt.*

Domestic Water Supplies by Meter. C. C. Judson, Wtr. & Wtr. Eng. (Gt. Br.) **52**:36 (Jan. '49). Advantages of metering all supplies are: [1] consumption undoubtedly reduced and [2] leakages on supply pipes automatically checked at quarterly readings of meters. At Malvern, although reading of meters absorbs attention of several of staff for few weeks each quarter, need for waste inspection reduced, and balance is in favor of meter method of checking waste. Disadvantages are that work of department somewhat disorganized during period of meter survey and leakage can commence shortly after one survey and not be checked until next meter reading. If only consideration were economic, system of charging for domestic water by meter would present obvious advantages over method based on rentable value of property supplied. Arguments can be brought forward that dweller in low-rated property should be charged less than true value of water. Many anomalies in ratable (rentable) value system, but consumer takes system for granted. Forced to conclusion that water ought to be charged for by measure and not on some artificial basis.—*H. E. Babbitt.*

The Problem of Selling Water by Meter—Experience at Brussels. J. Rensburg. Wtr. & Wtr. Eng. (Gt. Br.) **52**:342 (July '49). (From La Technique de l'Eau (Belg.).) Flat rates do not encourage consumer to economize, and waste increases to such proportions that possession of enormous resources necessary. From 1891 to 1922 Brussels had 21 different kinds of meters. In '21 $\frac{1}{3}$–$\frac{1}{2}$ no longer registered and rest registered with low accuracy. System of charging for min. consumption assured regular income. Nearly 150,000 velocity type meters now in service. Meter composed of paddlewheel mounted on vertical shaft revolving inside chamber connected to entry and exit ports. Force of jets acts on vanes, rotating wheel proportional to discharge. Counter registers number of revolutions of paddle. Meter shop repairs about 15,000 meters annually. Following conditions must be fulfilled by new, 13-mm. meters: [1] initial discharge of 15 l./hr., 50% registration; [2] above 30 l., 100% ± 3%; [3] discharge characteristic 3 cu.m./hr. with 10 m. loss of head. Futile to try to improve initial sensitivity, as reception conditions do not hold after several years of service on account of hardness of Brussels water supplies. Unaccounted-for water results from leaks, unmetered use such as for fire fighting, and, principally, nonregistration by individual meters at small flows. Percentage of supply unregistered from '34 to '47 varied between 32.5 and 44.0, showing no definite trend. Experiments indicated max. of 21% unaccounted-for water due to lack of sensitivity of velocity meters. Among new types of meters

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(*Continued from page 54*)

tested, rotary piston prominent. It is semipositive type in sense that revolution of rotary piston lets pass vol. of water equal to 34.8 ml. During 3 yr. of tests all meters began to measure at 1 l./hr. and registered 100% at 15 l./hr.—*H. E. Babbitt.*

TREATMENT—GENERAL

Water Softening. Report of Investigation by Official Committee. Anon. Wtr. & Wtr. Eng. (Gt. Br.) **53**:19 (Jan. '50). Report of Water Softening Subcommittee of Central Advisory Water Committee published by Ministry of Health. Committee asked to investigate in particular whether desirable and practicable that public water supplies in hard-water areas should be softened; effect of softening on finances of water supply industry and resultant cost to consumers; degree of hardness to which water softening desirable and effect on industry if softened water supplied. Report divided into 5 main parts: [1] general considerations, including cause of hardness, its det., classification of waters, methods of softening and hardness of British water supplies; [2] alleged disadvantages of hard and soft waters; [3] methods of overcoming disadvantages of hard water; [4] use of water in industry and softening of public water supplies; and [5] softening processes and their cost. Full details of soap test and potassium palmitate test given in appendix. Hardness has little or no signif. in relation to health. Total wastage of soap, in water of 200-ppm. hardness, 2.74 oz./cap. weekly or about 8.9 lb. annually. Soap curd estd. to cost approx. 10*s.* per capita annually. Although scale production does increase fuel cost, increase not very large. No strong argument for or against softening of water as regards brewing of tea. Belief that hard water less effective in coffee making not so extensively held. Only rather serious disadvantage of soft water is that it may be corrosive to certain metals. Methods of overcoming disadvantages of hard water include: [1] use of reagents, [2] use of cleaning materials (i.e., synthetic detergents), [3] use of domestic water softeners and [4] use of reagents and devices to prevent deposition of scale in water heaters. Cost of reagents (lime-soda) for removal of 200 ppm. of hardness from 1000 gal. (Imp.) of water, before distr., is as follows: temporary hardness (Ca), 0.374*d.*; temporary (Mg), 0.748*d.*; permanent (Ca), 1.91*d.*; and permanent (Mg), 2.28*d.* Total cost of lime-softened water, including labor, etc., about 3.0*d.* In base-exchange softening, with salt at 95*s.* per ton, salt for removal of 200 ppm. of hardness from 1000 gal. (Imp.) of water would cost 2.3*d.* Labor cost likely to be 0.6*d.* and capital costs taken as 0.5*d.* Total cost avg. about 4*d.* On basis of 30 gal. (Imp.) per capita per day and 4*d.* per 1000 gal. (Imp.), cost of central water softening will be about 4*s.* per capita yearly. Impossible to state with precision any hardness figure above which water should be softened, or any figure which softening should aim to achieve. —*H. E. Babbitt.*

Water Softening Reagents Produced From Softening Sludge. Rudolph E. Thompson. Wtr. & Sew. (Can.) **87**:1:22 (Jan. '49). Principles and reactions of softening by pptn. reviewed. Softening and recarbonation consists essentially of converting soluble Ca and Mg salts to insoluble compds. and, after removing bulk of latter, of reconverting residual to stable soluble form. Sludge can be sepd. again into constituents, which are reagents used in softening and recarbonation. Logical, therefore, to utilize sludge, which cre-

(*Continued on page 58*)

(Continued from page 56)

ates disposal problem, for this purpose. This is being practiced at several plants described.—*R. E. Thompson.*

Modern Substitutes for Soap. ANON. Wtr. & Wtr. Eng. (Gt. Br.) **52**:458 (Sept. '49). Newest agents used in place of soap divided into several types: [1] turkey red oil, produced by combination of castor oil and sulfuric acid; [2] alkyl sulfates, produced by sulfating higher alcs. (example, "Teepol"); and [3] alkyl esters and amides, and alkyl sulfonates in which sulfur atom directly attached to one of carbon atoms in carbon chain (example, German "Mersolate"). Substances so far considered all similar to soap, being compds. of alkali metal, sodium, with org. radical; known as "anion active" agents. "Reversed soaps" have recently been developed, cation active and highly stable toward acids, though not towards alkalis (example, "Fixanol"). Some wetting agents, known as nonionic ("Lissapol N"), have good cold-water wetting properties, are useful detergents and possess good stability toward hard water, acids and alkalis. Despite many diverse applications of synthetic wetting agents and detergents in industry, main outlet undoubtedly destined to be in domestic sphere to replace or augment soap. Outstanding advantage is resistance to hard water and absence of scum formation. Since in many parts of England domestic water hard, availability of detergent effective under such circumstances of real value.—*H. E. Babbitt.*

Extraction of Salt From Sea Water. TOYOTARO NAGAI, TARO MORISE, MITSUGU YAMAMOTO & KIYOKO IWATA. Research Report Osaka Munic. Inst. Domestic Sci. (Japan) **17**:483 ('46). Tests made to find simple method of extracting salt from sea water by using ion-exchange method. Goseijuyu (resins) method, described by Adams and Holmes, studied. This method used by I. G. Farben. of Germany and Resinous Products Chem. Co. of U.S.A. to produce suitable water softener. With 60 g. of cation-exchange resins per l. of sea water, only 6% of salt extracted; method under further study. By using Ag_2CO_3 and Ca-Parmuchito, salt content was brought to 2000–3000 ppm. from 1 l. of sea water; 150 g. of Ag_2CO_3 and Ca-Parmuchito was used over and over again.—*C.A.*

The Extraction of Salt From Sea Water. HIROSHI NISHIHARA. Research Report Osaka Munic. Inst. Domestic Sci. (Japan) **17**:471 ('46). Salt extracted from sea water by using silver carbonate and citric acid, silver carbonate and tartaric acid, and silver carbonate and maleic acid. With humans as subjects, found that after drinking 1 l. of water treated by each of 3 methods, degree of thirst as follows: water treated with silver carbonate–citric acid produced greater thirst than that treated with silver carbonate–tartaric acid. Degree of thirst produced by water treated with silver carbonate–tartaric acid equaled that produced by water treated with silver carbonate and maleic acid. No cases of diarrhea reported by those drinking silver carbonate–citric acid water. Effect of drinking water treated with silver carbonate–tartaric acid not known. Diarrhea reported by those drinking water treated with silver carbonate and maleic acid. No cases of fever, stomach pains, loss of appetite or nausea reported by those drinking water treated by any of 3 methods.—*C.A.*

Removal of Iron From Drinking Water Under Field Conditions. T. I. GOLUBEV. Gigiena i Sanit. (U.S.S.R.), **12**:10:24 ('47). Well water contg. up to 30 ppm. FeO can be essentially freed from Fe (residual 0.1

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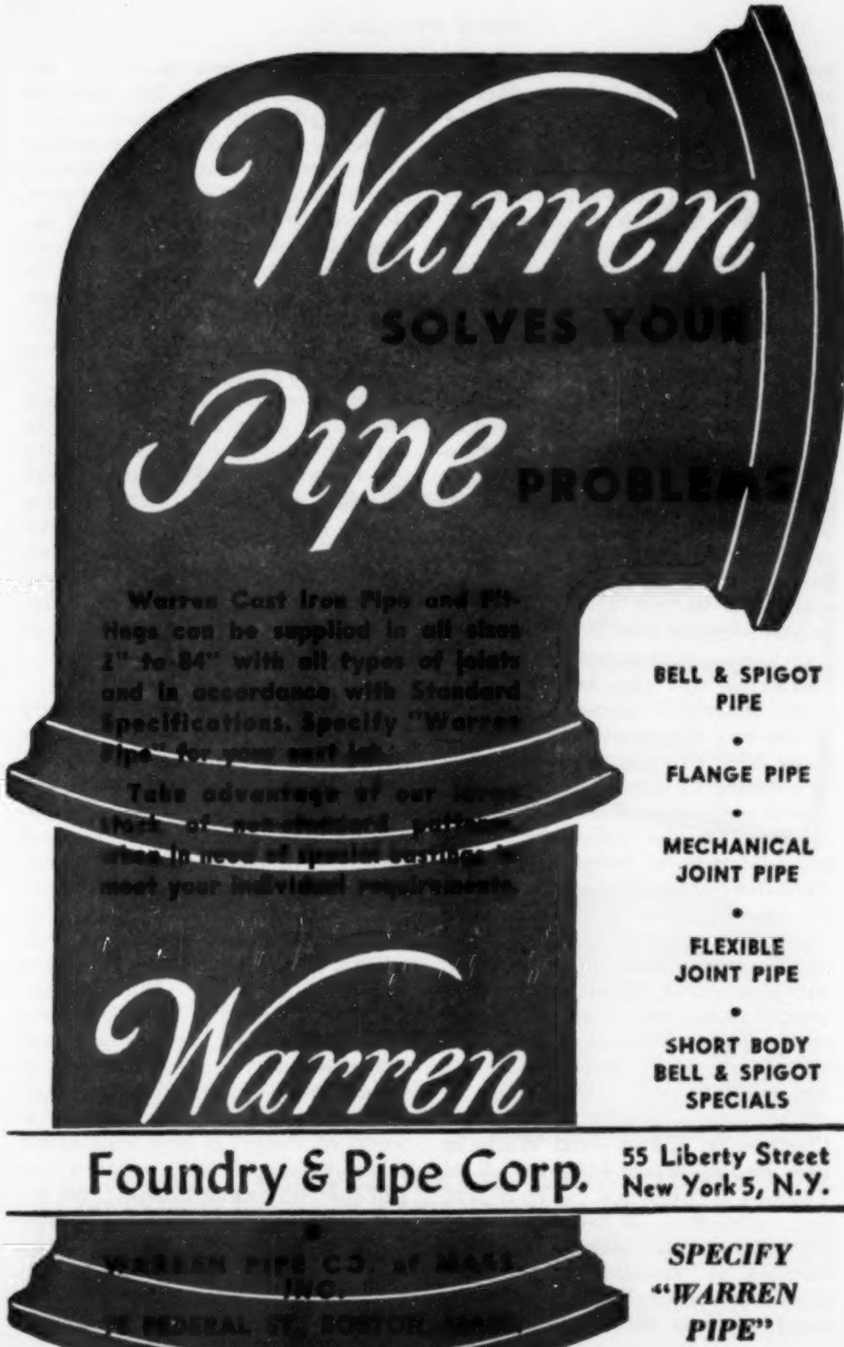
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ppm.) by treating with chlorinated lime and allowing to stand 2 hr., either at head of well or *in situ*; dosage must be detd. individually for each case. Somewhat more favorable results obtained by using gaseous Cl_2 *in situ*, which prevents undue water hardness.—*C.A.*

Experiments on "Excess Lime" Treatment of the Brantford Water Supply. D. B. WILLIAMS. Wtr. & Sew. (Can.) **87**:9:34 (Sept. '49). Lab. expts. showed that excess-lime treatment to slight hydroxide alky. effects greater reduction of albuminoid ammonia than coagulation with alum alone at any dosage. Higher dosages of lime do not appreciably increase reduction. Alum as coagulant aid to excess lime enhances reduction, but small dosages of lime as aid to coagulation with alum do not give appreciably greater reduction than coagulation with alum alone. Activated silica improved coagulation with alum but did not increase albuminoid ammonia reduction. Excess-lime and alum coagulation also much more effective than alum alone in reducing Cl demand, and resulting free Cl residuals more stable, persisting in stored samples for weeks. Taste and odor removal comparable to that from free residual chlorination effected by excess-lime treatment, and combination of 2 procedures gives results superior to either alone. Prior treatment with excess lime, by reducing high Cl demand caused by protein substances, renders free residual chlorination more economical and effective.—*R. E. Thompson.*

Clarification of Industrial Water by Floc Bed of Water Softener. R. S. YOUNG & A. GOLLEDGE. Wtr. & Wtr. Eng. (Gt. Br.) **52**:294 (June '49). Several years ago lime-soda softener installed at Rhokana Corp. Plant, Nkana, Northern Rhodesia, to treat water required for locomotives and power plant evaporators during dry season. This softener had capac. of 150,000 gpd. (Imp.) and produced conventional, rapid cold-water softening, wherein treated water flows upward through thick floc bed in vertical cone. However, troublesome scale still appeared on boiler tubes. Scale derived from clay and suspended matter in water and appeared to form aluminum silicate compd., hard to remove. To remove mud from raw water, it was passed from primary settling reservoir through floc bed of softener during wet season after softening had been discontinued. Practice of softening water when clear and filtering through floc when rainy season yields soft but muddy water has been employed for past 2 yr. Results have been satisfactory. Clay particles apparently adsorbed on floc. Entrained mud periodically drawn off with small quant. of floc.—*H. E. Babbitt.*

Sedimentation Basins and Accessory Safety Measures in Collectors for Springs. ROBERTO COLOSIMO. Giorn. Gen. Civ. (Italy), **86**:245 (May '48). Water from springs in limestone or granite areas generally carries small suspended particles during wet season. To obtain clear water, sedimentation basin built at outlet of spring, calcd. to settle particles down to $\frac{1}{10}$-mm. size. Several examples of such basins shown by plans and sections. (Where enough data given, period of retention calculates to 90–210 sec., with flow velocities of about 1"/sec.) Care taken to get uniform distribution of flow. Earlier basins had no provisions for removal of sludge; in later installations 1 sludge removal valve provided, and still later several such valves. All designs shown have only single sedimentation basin, requiring interruption of service during sludge removal. Special pipe arrangements then necessary to avoid water hammer in conduit

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when put in operation again. Basins have overflow weirs and bypasses to take care of yield from spring not used in conduit. Basins built underground, but, for sanitary protection, have inside glass cover. All valves handled from outside basin. Every conduit has measuring device, usually venturi meter. Cost of sedimentation basin only small part of total expense of outlet structure and conduit.—*Max Suter.*

Filtration With Addition of Air. A. H. M. Boelens. Water (Neth.) **33**:238 (Oct. 27, '49). Method of purifying and simultaneously removing iron, manganese and ammonia from water by alternating addn. of air to rapid sand filters has been used for swimming pool treatment but not as yet applied to potable water treatment. Studies with well water contg. iron difficult to remove (7.2 ppm. before and 4.1 ppm. after aeration) showed that after treatment, iron content reduced to less than 1 ppm. Free CO_2 (110.7 ppm.) removed to practically same extent, D.O. increased to 8.3–10.3 ppm. Contrary to present theory and practice aeration of filters as well as water important, particularly where iron compds. cannot be removed with usual methods. Sand sizes used 1–1.5 mm.—*W. Rudolfs.*

A New Filter Bottom Construction. C. W. Hulsbergen. Water (Neth.) **33**:243 (Oct. 27, '49). Good filter bottom should not be affected by variations in flow (backwashing), should be washable with water or air, must be thin, require no maint., be easily replaceable, be easy to install, readily available and inexpensive. New type of bottom constr. consists of aluminum slit nozzle caps screwed into holders, which in turn fastened about 4″ into 2″-thick, 28 × 28″ cement plates or into steel plates.—*W. Rudolfs.*

EUROPEAN SUPPLIES

Highlights in the Development and Operation of the Vienna Water Works. A. Steinwender. Gas, Wasser, Wärme (Austria) **3**:155 (Aug. '49). Since beginning of development question of mountain springs or ground water supply debated. Ground water considered good for industrial but not for potable use. This view changed because of increased danger of poln. With daily water consumption of 132 mgd., cost of collection and storage high. Separation of potable and industrial water, using mountain springs and canal or ground water, respectively, requires duplication of distr. systems and industrial water would still need to be safe for human use. Chlorination of water valuable but should not be used if it can be avoided. Vienna water supply chlorinated since '45 because of bomb and other war damage. Hoped that when peace declared this costly procedure can be abandoned. In future further development of mountain springs probably economically unsound, but to construct very large basins to store ground water also costly. Combination of 2 sources of supply considered most practicable.—*W. Rudolfs.*

Iceland's Municipal Hot Water Systems. Frank Illingworth. Wtr. & Wtr. Eng. (Gt. Br.) **52**:437 (Sept. '49). Near Reykjavik, engrs. drilling to depth of 1200′ for natural hot water to supply new suburbs. Reykjavik and Sellfoss remain only towns in world with hot-water street mains on city-wide scale. Reykjavik system conceived in '28. Installation proved success and in '34 extended to approx. ½ of city. Foremost problem insulation of mains, since springs 10 mi. from city and winter temp. low. Insulating materials selected: for main pipes—lava slag and peat; for urban street mains—

(Continued on page 66)

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BURSTING STRENGTH

In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

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The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times *on the same spot* from progressively increased heights of 6 inches.

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The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

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When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

SERVES FOR CENTURIES

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porous lava slag; and for house piping—glass wool, tarred paper and bitumen sheets, melted together at edges. Avg. temp. of water from boreholes 87°C. Water piped from wells through 9400' of steel pipe 4–12" in diam. to cistern near pumping station. Station comprises 3 units, each driven by 300-hp. elec. motor and capable of discharging 1980 gpm. (Imp.) against head of 460'. With max. requirements 2 units operated. From pumping station water flows through double 14" steel pipes to concrete tanks with capac. of 242,000 gal. (Imp.), on hill overlooking Reykjavik. Altitude of tanks permits gravity flow to city, but pumping station has been built to maint. pressure in event of heavy demands. Insulation has proved so good that in coldest winter temp. drop is only 5–6°C. to furthest home using system. Piping in town exposed to great changes in temp. Expansion joints inserted at proper intervals. Flexible pipes made of copper alloy also inserted. Street lines laid on iron supports which prevent sagging. Expansion of house lines provided for by zigzag bends, insulation coating being loose enough to permit expansion between bends. Expansion gaps in concrete channels packed with bitumen, tarred paper and hemp. Urban system has considerable number of valves and expansion joints, around all of which concrete boxes built. Where channels slope toward box, drain leads to sewer system. Traps prevent sewage vapor from entering box. Stopcock installed on each house line close to its connection to street line. Newly laid house lines connected straight to central heating system close to (house) boiler. Meter, control valve for daily regulation of flow, and check valve installed. Water for bath and wash basins taken from line before it enters heating system. Tenant of 5-room flat pays 15*s.* per week in winter; in summer about 7*s.* Running expenses low. In 1948 board made profit of £50,000 on initial outlay of £1,000,000.—*H. E. Babbitt.*

Water Supply for Amsterdam. L. Huisman. Water (Neth.) **33**:255 (Nov. 10, '49). Larger rivers (Rhine, Lek) available for supply, but contain material quants. of chlorides and odor- and taste-producing substances. At low flows org. impurities already high. Min. flow recorded during '20–'47, 74 cu.m./sec., avg. 430. Flow of less than 200 cu.m./sec. occurs less than 19 days in 100. Flows of less than 100 cu.m./sec. for period of 50 days/yr. may be expected every 73 yr., and for period of 15 days, every 11 yr.—*W. Rudolfs.*

Review of Water Supply in the Netherlands. B. F. van Nievelt. Water (Neth.) **33**:187 (Sept. 13, '49). First water works established at Amsterdam in 1853; now 180 public and 22 private companies, which delivered about 76 bil.gal. in '47 to 80% of pop. Max. yield of dune water 50,000,000 cu.m./yr. and ground water 100,000,000 cu.m., while future annual requirements are 385 cu.m.; difference to be obtained from surface waters. Hydrological conditions unfavorable. Consumption low; for instance, The Hague, Haarlem and Amsterdam per capita use 32, 19 and 14 gpd., respectively. Reasons for low consumption: many industries have own supplies; std. water closets have capac. of 2 gal. with no leakage; strict plumbing rules. Many studies made by government and water works agencies pertaining to standardization, corrosion, hydraulics, ground water, coagulation, filtration, algae growth, etc. Purif. of ground waters almost entirely limited to removal of iron and manganese and corrosion prevention. In general, iron and manganese removed by aeration and rapid sand filtration, oxidation

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stimulated by addn. of potassium permanganate.—*W. Rudolfs.*

Fluorine in Polish Water Supplies. JANINA DŁUYŃSKA & JAN JUST. Gaz, Woda i Tech. Sanit. (Poland) **23**:228 (July–Aug. '49). Anals. made of fluorine content of Polish water supplies. In future addnl. well supplies will be examd. to obtain more complete picture of distr. of fluorine in waters used for drinking, culinary and food-processing purposes. 334 munic. and public water supplies examd. Of this number only 6 showed fluorine in excess of 1 ppm. F (highest reported 3.2 ppm.), and 9 showed fluorine varying from 0.5 to 1.0 ppm. As result mottled enamel reportedly does not constitute serious problem in Poland. Authors state that should prophylactic addn. of fluorine as currently practiced in U.S. prove of value, such addns. may be proposed for those supplies deficient in fluorine.—*Conrad P. Straub.*

The Malmö Water Works at Vomb [Sweden]. ALFRED JERDEN. Wtr. & Wtr. Eng. (Gt. Br.) **53**:3 (Jan. '50). Malmö water works largest in Sweden using ground water. In '48 Malmö had pop. of 185,947 and water consumption of 3100 mil.gal. (Imp.). Up to '40 ground water from preglacial sand stratum exclusively used, quant. available being 8 mgd. (Imp.). Central pumping station situated 21 mi. from center of town. When ground water no longer sufficient, intended to amplify rainfall by pumping lake water to more elevated wooded parts of area. Main plant constructed for 10 mgd. (Imp.). 25 wells built. Water raised by shaft-driven borehole pumps. Each well delivers 500,000 gpd. (Imp.). Water flows in conduits to 2 suction wells outside central pumping station. Main pressure pipe rises over hills. At highest point, 5 mi. from pumping station, reservoir of about 800,000 gal. (Imp.) capac. has been constructed. Pumping plant to consist of 6 vertical-spindle, electrically driven centrifugal pumps, each of 4000-gpm. (Imp.) capacity at 200 ft. head. Distance between pumping station at Vomb and water works buildings in Malmö about 18½ mi. 36″ pipeline carries water. Pipe consists of ⅛″ steel plate covered externally and internally with reinforced concrete. Cost, exclusive of pipeline to Lund and grounds at Vomb, amounts to £800,000.—*H. E. Babbitt.*

District Water Supplies in Switzerland. ANON. Wtr. & Wtr. Eng. (Gt. Br.) **52**:543 (Nov. '49). In Switzerland surface water little used for human requirements. Brief acct. of water works of Freiberge, in canton of Berne, typical. In lower-lying valleys of neighboring rivers Suze and Doubs, there is abundance of ground water, which is collected in 2 wells and delivered by low-lift pumps into daily service tank with capac. of about 44,000 gal. (Imp.). High-lift pumping station, with 2 pumps of 265-gpm. (Imp.) capac., delivers water to high-level reservoir, with capac. of 330,000 gal. (Imp.), about 1770′ above station. From reservoir, water flows into distributing mains. Prelim. drillings showed that geological conditions throughout valley homogeneous. Pumping tests gave good results. Tests showed that 3 wells sufficient to supply all water required. 12-stage, high-lift centrifugal pumps fitted with Sulzer balancing discs, bronze impellers and guide wheels, and high-grade, cast-iron, one-piece end covers. Each pump driven by horizontal, asynchronous 3-phase, 2940-rpm., 380-v., 50-cycle motor developing 220 hp. Each delivery pipe fitted with check valve having bypass electrically controlled and operated by servomotor, and also with stop valve controlled and operated in similar manner. Common delivery

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pipe conveys water into principal high-level reservoir. This pipe, about 1900 yd. long, rises about 1750′ and is divided into 3 sections, 8″ at bottom, 9″ and finally 10″ at top. Automatic equip. comprises remote-control, remote-indicating safety and alarm devices. First single water supply systems to be built in Switzerland were those of Aarau in 1860, Neuchatel in '62, Zurich in '64, Basle and Geneva in '65, Lausanne in '68 and Berne in '69. Geneva received as much water per capita 2000 yr. ago as today. It was supplied through Roman aqueduct of Cranves.—*H. E. Babbitt.*

ANNUAL REPORTS

Los Angeles Dept. of Water and Power. Report and Accounts of Water System (Year Ending June 30, 1948). Operating revenue $17,-812,743, total income $18,320,503, operating expense $8,671,668, interest and amortization charges $1,790,760, depreciation $3,179,062, net income $4,679,013. Water sold increased 2.8% and revenue therefrom 4.1% as result of addn. of 15,900 customers. Distr. mains 4519 mi., services 432,388, meters 365,597, hydrants 23,970. Total investment in plant and equip. $194,-572,899, depreciation reserve $52,-173,394, bonds outstanding $42,119,-349.59, earned surplus $65,544,250.81, city's equity $113,485,448.98. Avg. billing price per 100 cu.ft., 10.71¢. Avg. no. of customers 354,765.—*R. E. Thompson.*

Augusta (Me.) Water Dist. Annual Report (1948). Fixed assets $1,982,-655.23, long-term debt $481,500, earned surplus $377,623.91. Revenue $125,-213.82, operating expense including depreciation $88,545.28, net operating revenue $36,668.54, net loss $937. Supply from Carleton Pond and L. Cobbosseecontee, treated with Cl and lime, avg. dosages 6.4 and 32.6 lb. per mil.gal., respectively. Avg. consumption 2.66 mgd. Services 3780, mi. of mains 77.8, gate valves 778. Storage more than 16 mil.gal. History of water district included.—*R. E. Thompson.*

Worcester (Mass.) Bureau of Water. Annual Report (1948). Estd. pop. 204,143. Supply from impounding reservoirs (6520 mil.gal.), 67% gravity, 33% pumped, treated with chloramine. Max. consumption 30 mgd., avg. 22.5, 110 gpd. per capita. Water unaccounted for 12.74%. Revenue per capita $5.83. Cost of water per mil.gal.: at reservoirs $11.12, delivered to distr. system $16.50, delivered at faucet $51.06, exclusive of $1.69 and $26.10, interest and payments, respectively, on serial loans. Cost of chloramine treatment $1.30 per mil.gal. Chemicals used: Cl 36,632 lb., NH_3 6805 lb. 37° (24-hr.) count reduced from 40.2 to 11.6 per ml., 20° (48-hr.) count reduced from 190.6 to 53.1, *Esch. coli* per 100 ml. reduced from 2.18 to 1.19. Turbidity 4, color 18, hardness 25 ppm., pH 6.4. Mains 446 mi., services 305 mi., hydrants 3849, valves 6179, services 34,117, meters 30,091 (99.7% of active services metered). Maint. cost per hydrant $12.36. Pressure 20–200 psi. Receipts $1,217,558.01, operating expense $403,740.72, interest $13,900, retirement of bonds and notes $215,000, excess of receipts over expenditures $579,917.29. Value of plant $15,015,-261.49, outstanding bonds $1,192,000.—*R. E. Thompson.*

Richmond (Va.) Dept. of Public Utilities. Annual Report (Feb. 1, 1947, Through June 30, 1948). Peak demand 42 mgd., but 30-mgd. plant operated successfully under heavy overload. Contract awarded for 36-mgd. addn. Pop. 230,200, water customers 52,134, customers per mi. of

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main 97.8, avg. consumption 30.62 mgd., 130 gpd. per capita. Water revenue $2,008,081.24; operating expense $899,884.89; depreciation, taxes and interest $1,038,654.99; net income $69,541.36. Net debt $3,615,649.54. Cost of purif. $12.77 per mil.gal., of which $2.78 for coagulants and $1.47 for Cl. Total cost, including depreciation, taxes and interest, $122.97 per mil.gal., or 9.23¢ per 100 cu.ft. Rates per 100 cu.ft., 6–15¢ with min. monthly bill of $1; outside city, 6.5–32.5¢ and $2.10, respectively. Avg. chem. dosages, lb. per mil.gal.: before filtration—Cl 27.2, SO_2 2.1, activated C 5.8; after filtration—NH_3 2.5, Cl 9.1, CaO 50. Coagulation with alum or chlorinated copperas. $CuSO_4$ also used. Avg. filter run 73 hr. Avg. turbidity reduced from 28 to 0.1 ppm., color from 69 to 2.1, 37° count from 852 to 0.02 per ml. Positive presumptive coliform tests on finished water: 100 ml., 1, 10 ml., 0. Mains 532 mi., hydrants 3225, meters 52,877.—*R. E. Thompson.*

Aberdeen (Wash.) Water Dept. Income, Profit and Loss Statement (Dec. 1948). Operating revenue $247,281.57, operating expense $168,-977.25, net revenue after allowing for interest and taxes $51,997.13. Fixed assets $3,233,533.88. Investments, special funds, current and deferred assets increase total to $3,583,140.21. Surplus $1,300,695.72. Capital liabilities $586,000.—*R. E. Thompson.*

Seattle (Wash.) Water Dept. Annual Report (1948). Metered water revenue $3,126,299.13, decrease of $287,828.89. Peak demand 138 mgd., decrease of 28, due almost entirely to record rainfall during sprinkling season. Cost of operation increased $178,369.61 and net income decreased from $689,791.98 in '47 to $256,067.75. No fires on watershed for second yr. since 1900. Funded debt $2,299,000, surplus (city's equity) $26,683,361.04. Cost of billing and collecting 113,740 accts. $1.408 per acct. per yr. Avg. daily metered consumption 61.7 mgd., estd. municipal service 7 mgd. Unit revenue per 100 cu.ft. 10.83¢, cost 9.02¢ ($120.31 per mil.gal.), of which 5.41¢ for operation and maint. Distr. storage 362.5 mil.gal. Distr. mains 1131.6 mi., supply mains 77.1 mi., hydrants 10,916, valves 9965, meters 115,346. Meters repaired: percentage of meters in use 7, avg. months of service 107, avg. cost $3.14. Cedar R. water contains total solids 42 and hardness 22.1 ppm., and has pH value 7.3. Estd. pop. served 579,057, 100% metered. Per capita consumption 132 gpd. Pressure 25–125 psi.—*R. E. Thompson.*

PIPELINE MATERIALS

Asbestos-Cement Pipes in Holland. Anon. Wtr. & Wtr. Eng. (Gt. Br.) **52**:505 (Oct. '49). From report issued by Commission for Study of Water Supply Technique in Holland. General opinion in Holland about results obtained from asbestos-cement pipe favorable. Usually decision to employ this material inspired by economy, immunity from chem. influences, small loss of head, and insensibility to stray currents. Tests showed that material not absolutely watertight, but perviousness to water so slight as to be of no practical signif. From results of expts., concluded that preference should be given to testing of material after complete immersion in water for 7 days. On basis of tests, commission considers following as reasonable for testing purposes: tensile strength, at least 2280 psi.; strength to ring pressure, at least 6390 psi.; bending tensile strength, at least 3195 psi. Danger of corrosion exists only in very acid soil with pH between 1 and 3, or

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soil that is alternately aerobic and anaerobic. Presence of sulfates and magnesium salts in ground water may cause formation of double salts with calcium from cement, accompanied by increase in vol. of latter, which may lead to destruction of pipes. Coating of satisfactory thickness obtained with bitumen, applied hot, after prelim. prepn. of pipe; this layer adhered quite well at first; later, however, it was pushed off surface when pipe subjected to hydraulic pressure, owing to perviousness of asbestos cement. Commission suggests that mains be tested for watertightness immediately after being placed in trench, no water test to be made for 2–3 weeks thereafter.—*H. E. Babbitt.*

Prestressed Reinforced Concrete Water Pipes. ROLT HAMMOND. Wtr. & Wtr. Eng. (Gt. Br.) **52**:497 (Oct. '49). In conventional type of precast reinforced concrete pipe, steel reinforcement bonded into concrete at time of mfg., with result that relations between stresses in concrete and steel fixed and minor cracks must inevitably be accepted. When such pipe employed as conduit for conveying water under pressure, shell subjected to tensile stress against which concrete weak. In prestressing concrete pipe, engr. tries artificially to improve tensile strength of concrete by imposing on material prelim. internal stress before water pressure applied within pipe. Prestressing applied by steel wires or bars which are stretched; if steel stretched before concrete set, pipe called "pretensioned"; if after, "posttensioned." Design of prestressed concrete member involves no new theory regarding working loads. Four British patents refer specifically to prestressed concrete pipes. In Freyssinet process, prestressed concrete water pipe can be produced in 3½ hr. Concrete vibrated, then compressed, then expanded by its initial pressure, and finally heated. Pipes designed for pressure of 40–70 psi. Reinforcement of Freyssinet pipe consists of high-tensile steel rods in which yield point raised to 113,000 psi. Concrete has high percentage of ordinary Portland cement mixed with fine aggregates. Largest of aggregates about 0.4″ for pipes with shell thickness of 2″, slightly larger size being used for pipes with greater shell thickness. Core, used in casting, consists of either forged or welded steel tube with rubber jacket. Water at high pressure introduced between steel core and outer rubber jacket; thus possible to enlarge diam. of core. Outer form detd. by series of I-beams bearing upon wooden staves, with their lower points resting on suspender ring. Since concrete highly compressed in 3 directions, under design pressures steel reinforcement has been prestressed to double working pressure, or about 78,000 psi., at which point concrete under no stress. System of controlled stress has been designed by W. C. Parmley. Specially coated steel hoop rods terminate in metal box castings and are embedded in shell of pipe at time of mfre. By turning nuts on ends of rods they can be tightened to produce any desired tensile stress in steel and to secure definite compressive stress in concrete. At Melbourne, Australia, firm of Rocla, Ltd., employs expansible steel core with sand packing. In this method, circumferential reinforcement in wall of pipe stretched before concrete set. Pipes made by centrifugal process and when removed from spinning machine are stood on end in molds. Water pressure of 200–3000 psi. applied to expansible sheet metal core. When concrete hardened, water pressure released and sand core removed but steel remains in tension. Pipes up to 20″ in diam. with 1½″ wall thickness have successfully resisted in-

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ternal water pressure of 130 psi. In South Africa, Superconcrete Pipes, Ltd., introduced method of prestressing longitudinal reinforcement, applicable to spun pipe. Reinforcement passed through holes in plates at ends of mold where bars held by clamps. Between one end of mold and clamp is screw by which bars can be stretched before mold rotated. In American method of Lewiston Concrete Pipe Co., pipes in 12′ lengths made as follows: major portion of pipe cast to thickness of 3½″ by spinning process, contg. only longitudinal reinforcement in form of small-diam. steel bars with washers at each end. After pipe cured in steam for 3 days, each bar stretched by nuts tightened with long-handled wrenches. Pipe lifted into position for applying circumferential reinforcement. Pipe next set in vertical position within metal mold, where 1″ coat of mortar applied to outside of shell. Tension in circumferential wire obtained partly by friction resulting from making several turns of wire around fixed wheel, and partly by resistance of drum to which wheel attached. Lock Joint Pipe Co., another American concern, employs cylinder of welded sheet steel with joint rings attached, which is tested by internal water pressure. Cylinder then lined with concrete. After concrete cured, ready for tension winding. Wire wound spirally while core spun in lathe. In America prestressed concrete pipes have been mfd. with external wrapping of high-tensile steel wire in lengths from 12′ to 16′ and up to 48″ in diam., with wall thickness of 3″. Pipe-making process in Czechoslovakia uses low tension during winding to keep bending and torsion stresses low. At same time wire heated so that tensile stress induced on cooling added to stress produced by winding. This known as Ruml process. In France, friction losses avoided in circumferential hooping by tensioning hoops with radially disposed hydraulic jacks instead of jacks ranged tangentially. Tests carried out by U.S. Bureau of Standards on pipes having internal diam. up to 30″. Max. internal pressure, 600 psi.; crushing strength, 12,300 psi.; and load carried at center of 14′ span, 140,000 lb. Prestressed reinforced concrete now well established process in water engineering.—*H. E. Babbitt.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

Bacterial Standards for Natural Waters. ABEL WOLMAN. Sew. & Indus. Wastes, **22**:3:346 (Mar. '50).

Reclamation of Water From Sewage and Industrial Wastes in Los Angeles County. RUSSELL G. LUDWIG. Sew. & Indus. Wastes, **22**:3:289 (Mar. '50).

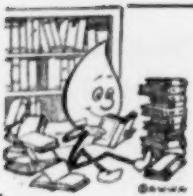
Industrial Waste Treatment—Symposium. Ind. Eng. Chem., **42**:594 (Apr. '50).

Correction of Reservoir Leakage at Great Falls Dam. A. H. WEBER. Proc. A.S.C.E. **76**:1:101 (Jan. '50).

Canadian Induced-Precipitation Experiments. D. FRASER, K. G. PETTIT & JOHN L. ORR. Eng. Jour. (Can.), **33**:3:177 (Mar. '50).

Corrosion of Steel Pipe by Chlorinated Sea Water at Various Velocities. V. B. VOLKENING. Corr., **6**:4:123 (Apr. '50).

Mechanical Pipe-laying Equipment—What and Whether to Buy. J. G. CARNS JR. Am. City, **65**:4:96 (Apr. '50).



The Reading Meter

An Index of Nomograms. *Douglas P. Adams, ed. The Technology Press of Massachusetts Institute of Technology and John Wiley & Sons, New York (1950) $4*

An invaluable addition to the technical library, this book might also earn its keep on the bookshelf of the practicing engineer or superintendent by referring him to some handy, time-saving devices. References to the sources of all nomograms are given under 21 main topic headings. A detailed subject cross-index helps diminish the book's chief defect, which is a failure to repeat items when they properly belong under more than one main topic heading. Thus some of the diagrams which appeared in publications serving the fields of "Hydraulics and Power," "Heating, Piping, etc.," and even "Mining" and "Mathematics," for example, are properly of interest also to those who might concentrate entirely on the "Water Works and Sewerage" section. Other defects include a failure to indicate the date up to which the literature searches were made, and occasional omissions, such as the Langelier stability diagrams from the February 1946 issue of this JOURNAL and Ebaugh's pumping cost chart from March 1949. In general, however, the volume is a substantial contribution to the bibliography of technology.

The Geology of Water Supply. *Cyril S. Fox. The Technical Press, London; distributed in U.S. by Sherwood Press, P.O. Box 1551, Washington 13, D.C. (1949) $6*

Chiefly concerned with those aspects of meteorology and geology which affect rainfall and, hence, water supply, in such regions as India, Afghanistan, Arabia, Abyssinia, and Burma, as well as continental Europe and Britain. A survey of hydrologic and geologic considerations, usual in such works, is supplemented by some interesting sections on geographic aspects (mud banks, floods, etc.), hillside stability, engineering foundations and works, and water quality. The portion on tests has little structural relation to the rest of the work, but a good portion of the book's value is in its loose-knit organization, which permits the author to draw heavily on his unusual and varied experiences. The addition of an index would have been helpful.

(Continued from page 22)

A New England Industrial Wastes Conference is to be held June 26–28 at Massachusetts Institute of Technology. The intention is to bring together representatives of industry, control agencies and engineers and research workers in a discussion of pollution and control problems. Prof. Rolf Eliassen and Clair N. Sawyer of M.I.T. are on the conference committee.

Our recent awakening to the fact that water runs in the A.W.W.A. family led senior member Edward Bartow to marshal the proof that it has always been so (see letter, P&R, p. 42). It is interesting to note, too, that the nine father and son combinations he lists (below) include three past-presidents (*) and one charter member (†). Thus, we continue our genealogical probe.

Father	FAMILY	Son
Frank C., Mgr., Water Co., Champaign, Ill. (June '02)	**Amsbary**	**Frank C., Jr.**, Mgr., Illinois Water Service Co., Champaign, Ill. (Jan. '27)
Edward S., Upper Montclair, N.J. (June '02)	**Cole**	**E. Shaw,** Chief Engr., Pitometer Co., New York, N.Y. (Oct. '38)
A. N., Supt., Water Works, Des Moines, Iowa (June '86)*	**Denman**	**Charles S.**, Gen. Mgr., Water Works, Des Moines, Iowa (Dec. '15)
J. M., Supt., Water Works, Troy, N.Y. (Apr. '84)*	**Diven**	**J. M., Jr.**, Engr., The Leadite Co., Jackson Heights, N.Y. (June '13)
Michael, Davenport Water Co., Davenport, Iowa (Mar. '81)†	**Donahue**	**J. P.**, Secy.-Treas., Davenport Water Co., Davenport, Iowa (Apr. '84)*
Harrison P., Metcalf & Eddy, Boston, Mass. (May '25)	**Eddy**	**Harrison P., Jr.**, Metcalf & Eddy, Boston, Mass. (Apr. '30)
W. R., Supt., Citizens Water Works Com., Quincy, Ill. (July '07)	**Gelston**	**W. R.**, Supt., Water Com., Quincy, Ill. (Jan. '42)
Allen, Civ. Engr., New York, N.Y. (May '96)	**Hazen**	**Richard,** Malcolm Pirnie Engrs., New York, N.Y. (July '37)
William, Supt., Water Works, Muscatine, Iowa (Mar. '82)	**Molis**	**Walter W.**, Supt. of Distr., Water Works, Muscatine, Iowa (July '35)

Francis S. Friel, consultant of Albright & Friel, Philadelphia, has been appointed to fill a vacancy in the Board of Directors of the American Society of Civil Engineers.

(Continued on page 82)


Brass Goods for
Water Service
Gas Service
Fire Protection
J
JAMES
JONES
COMPANY
LEROY AND ST. JOHN STREETS
LOS ANGELES 12, CALIFORNIA
Write for catalog "J"

(Continued from page 80)

N. T. Veatch, past-president of A.W.W.A. and consultant of Black & Veatch, Kansas City, Mo., has been reappointed by President Truman, along with the other five nongovernment members, to a second one-year term on the eleven-man Water Pollution Control Advisory Board. The board was created by the Water Pollution Control Act of 1948 to review U.S.P.H.S. pollution control activities and make recommendations to Surgeon General Scheele. Grants for pollution study under the act were terminated for the current fiscal year with nearly all of an initial $1,000,000 appropriation disbursed to various states and agencies.

Dr. Everett P. Partridge, director of research for Calgon, Inc., and Hall Laboratories, is succeeding Dr. Ralph E. Hall as director of both organizations. Dr. Hall, who remains with the firm as a consultant, was honored on the occasion of his 25th anniversary with the firm—a subsidiary of Hagan Corp.—by a celebration which took four days and covered 3,000 miles, via two private Pullman cars which took the celebrants from Pittsburgh to Florida and back. The chairman and one other member of the board of directors are located in Vero Beach, Fla.

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(*Continued from page 82*)

Both animal and vegetable descended upon New York City simultaneously last month to create still another crisis in water, for both the circus and the flower show are large-scale water consumers. What with brand new regulations prohibiting the watering of lawns, gardens and sidewalks as well as placing drastic limitations upon the use of water in refrigeration and air-conditioning equipment, New Yorkers were in little mood for the monkey business of weed feed.

Exhibitors in the International Flower Show, who depend upon water not only to keep their displays from wilting but for such props as fountains, brooks and waterfalls, made quick arrangements to import the precious liquid from their home communities and to reuse the supplies needed for their mechanical gadgets. At last reports, however, the circus had come up with no better measures than austerity and the possibility of washing elephants in the Hudson or in olive oil. For the hippos, at least, an austerity program will merely place them on a par with their uncaptured and uncaptivating kind in Africa, where the drought has killed off many and made the rest puddle-huddlers in the mud of what used to be Lake Rukwa in Tanganyika.

Meanwhile, the drought bout goes on and the deluge of solutions to the problem pours in with every mail. A Montreal man has asked for $5,000 as a fee for starting his electrostatic vapor discharger; a Detroiter asks $10.49 for creating a shower, $50 per thunderstorm and $100 per blizzard (in season); a Bridgeport inventor, of "sound mind, second to none," asked water department officials to view his rainmaking invention; a Brooklynite suggested picking up ice cakes from other states and dropping them in the reservoirs; diviners from all over the world have volunteered their services; and someone thought it would be a good idea to stop advertising pills that required water as a chaser. But what has apparently been most successful in boosting water levels in the reservoirs has been the threat of cloud bombardment by the scientific rainmakers. Poised for some time now to make their first experiment, they have been thwarted almost every day by rain. And if some overanxious amateurs are getting into that act, too, they apparently haven't been, or even claimed to be, successful.

Right now, New York's reservoirs are some 75 per cent full, the increase due entirely to natural precipitation and unnatural conservation. But if the screwballs and the scientists haven't yet added a drop to the bucket directly, they have been of tremendous value indirectly in keeping the shortage and the need for conservation constantly in the public eye. And if the bus line operator who wants to sell his services to the water department in operating tours of the reservoir areas to make New Yorkers more aware of the shortage is a little late in coming forward, he at least has the right idea.

Anyway the camels are in their element.

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Join the Parade!

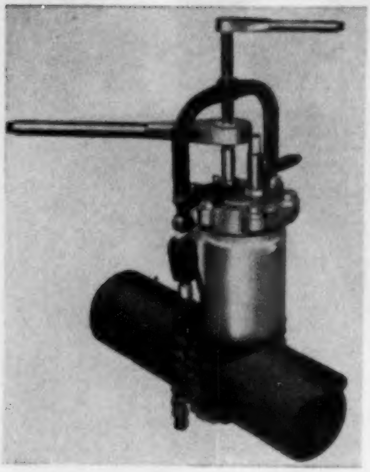
(*Continued from page 84*)

The water word is The Word these days—at least in the New York metropolitan area. Having been firmly established in the public consciousness during the depth of the drought it has now snowballed into enough prominence to merit exploitation as an "Open Sesame" to public attention. Thus, when the New York Public Library began lobbying for a bigger slice of the city budget, it entitled its appeal "Reservoirs Reach Serious Low" and told its whole story of librarian and money shortages in water works terms. And when the *Journal-American* sponsored a baby picture contest, one perspicacious parent made sure of a prize by labeling the photo of her bawling baby "The Superintendent of the Water Works." But not only these climbers-on the water wagon, every editor has developed an acute awareness of the worth of water stories. So when news broke of an airborne fungus that may destroy oak trees, in much the same manner as American chestnuts were killed 40 years ago, it was immediately assayed in terms of its possible destruction of watershed cover. And little items like the lawsuit of the British Royal Automobile Club against the Leeds City Council to protect its members against an extra levy of 50¢ a quarter for automobile washwater have progressed from the wastebasket to the front page. Meanwhile, editorialists, even of such serious publications as *Nucleonics,* have discovered water worthy of their most profound consideration; and water letters-to-the-editor have been given highest publication priority. Even though rainfall and new reservoirs will quickly dissipate its present momentum, we can hope that this favorite snowball of ours will not completely disintegrate upon impact with adequacy and that, having successfully weathered a place in the sun, it will not then quickly melt away in the shade.

But speaking of words, we were most interested to note recently that the Academy of Sciences of the Soviet Union is now ready to "cleanse" Russian science and technology of foreign words. Borrowing a phrase from Wallace & Tiernan, we might well observe that in Russia, apparently, "The Only Safe Science Is a Sterilized Science."

(*Continued on page 88*)

(*Continued from page 86*)



A new tapping machine—the Hays Model "B"—has been produced for drilling, tapping and installing corporation stops in mains under full pressure. The machine is said to offer faster and easier operation on the installation of all standard makes of stops in the ½- to 1-in. size range. The machine is fully loaded before being installed on the main and its use prevents troublesome shutdowns, with their consequent danger of contamination.

Additional information is available from the Hays Mfg. Co., Erie, Pa.

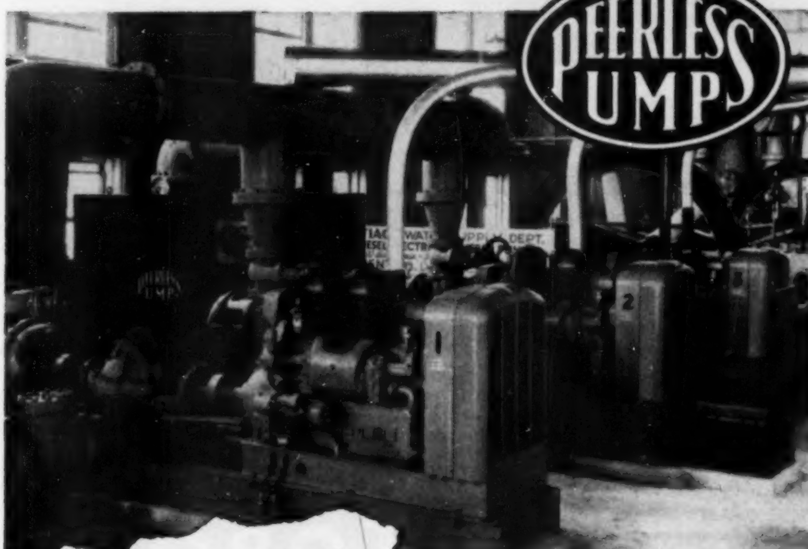
Attractive working conditions are an integral part of management's technique in competing for personnel these days, but we hadn't realized how advanced the movement was until the other day, when Myron Mansfield reported noting the following item in a set of specifications issued by the registered architect and engineer on a pipe-laying job for a brewery:

> Free beer will be served for fifteen minutes at lunch time and after the regular work hours of the Contractors, for regular employees of the Contractors working on the project.

Remembering that Joe Schwada, chairman of the committee which developed A.W.W.A.'s new pipe-laying specs, came from *famous* Milwaukee, we had a sudden suspicion, but close examination of our 7D.1–T document demonstrated the injustice of our thought. The fact that the specification was original with the firm involved, however, should not bar its adoption by other organizations. As a matter of fact, we're willing right now to sign up with any contractor who can get a similar deal on a job for a bank.

(*Continued on page 90*)

DIESEL POWERED MUNICIPAL PUMPING STATION REPORTS PUMPING COSTS CUT 25%



Three New Pumps Replace One Old

The age of the damaged pump and high cost of repairs militated against any attempts to put it back in operation, and thus the decision was made to replace it with the three horizontal centrifugal pumps. The pumps selected were Peerless Pumps, characterized by the occurrence of normal operation in the 87% efficiency range. Normal operation, dictated by the top level of elevated storage, is at 67 pounds' pressure and 2,500 gpm.

Reprinted from American City Magazine, February, 1950

87% EFFICIENCY RANGE CHARACTERIZES PEERLESS PUMP INSTALLATION FOR EASTERN CITY

Municipalities count high efficiencies over extended pumping periods as only one reason for their acceptance of Peerless centrifugal pumps. Dependability, ease of maintenance, widest capacity range, quality construction set the Peerless standard for pump performance and operating economy. Look to Peerless for continued leadership in pumping water at measurable savings. Write today for Bulletin B-1300 describing and illustrating Peerless Type A horizontal pumps, shown installed in the photo above.

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION
Factories: Los Angeles, California, and Indianapolis, Indiana
Offices: New York; Atlanta; Fresno; Los Angeles; Chicago; St. Louis; Phoenix; Dallas, Plainview and Lubbock, Texas.

(Continued from page 88)

The dedication of its new quarters at 345 Harris Ave. marked the celebration on March 31 of the 130th anniversary of the related Providence, R.I., firms of Builders Iron Foundry, Builders-Providence, Proportioneers and Omega Machine Co.

Taking part in the ceremonies were Mrs. Henry S. Chafee, wife of the company's president, who cut the ribbon at the door of the new office building (left to right in the view above); Rhode Island Governor John O. Pastore; Henry S. Chafee; Providence Mayor Dennis J. Roberts; and Earl H. Bradley, executive vice-president of the company.

A mobile FM radio system utilizing selective calling has been installed by the Chicago Water Dept. The system connects pumping stations, intake cribs, a patrol tugboat, and chief engineer DeBerard's private car to department headquarters. The equipment was provided by Federal Telephone & Radio Corp.

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A recruiting program designed to staff technical health missions overseas is being undertaken by the Div. of International Health of the U.S. Public Health Service. Sanitary engineers, technicians and scientists are among those needed to carry out programs authorized by the Congress to strengthen mutual understanding between the people of the United States and other countries. Assignment will be made in the higher grades and additional allowances will be granted for overseas service. Application forms and further details are available from the Chief, Div. of International Health, Public Health Service, Federal Security Agency, Washington 25, D.C.

James I. Corbett, formerly city engineer for Menominee, Mich., has joined the consulting firm of Hitchcock and Estabrook, in charge of their Menominee office.

C. Kenyon Wells, formerly division engineer of the Long Beach, Calif., Water Dept., has been appointed assistant general manager and assistant chief engineer.

Carter Products Corp., producer of the Carlon pipe advertised on the facing page, advise that purchasers should specify Carlon "EF" pipe for potable water service. An otherwise similar pipe—Carlon "E"—cannot be used to carry liquids intended for human consumption.

Kennedy Valve Mfg. Co. has purchased the Semler Co. of Jeannette, Pa., manufacturer of cast-iron pipe fittings. The addition will round out the present Kennedy line of malleable iron and bronze fittings.

J. H. Barnett Jr. has been appointed general sales manager for Reilly Tar & Chemical Corp. Previously he had been plant manager in Chattanooga and more recently southern district sales manager.

Service Lines

A bulletin explaining and illustrating corrosion control in water tanks by cathodic protection is available from the Cathodic Rustproofing Co., Carrizo Springs, Tex.

Ammonia alum, potash alum and aluminum sulfate (iron free) are the subjects of three technical data sheets available, with samples, upon request from C. Tennant, Sons & Co. of New York, Empire State Bldg., New York 1. Each sheet contains descriptive information and specifications and describes common applications and methods of packing.

Laboratory microscopes of Bausch & Lomb Optical Co., Rochester 2, N.Y., are described in a new 24-page catalog, D–185, available for the asking. A price list is attached.

Factors to be considered in selecting metals are discussed at length in a 12-page booklet entitled "Corrosion and the Final Choice," published by International Nickel Co., 67 Wall St., New York 5. The article is by W. D. Mogerman and F. L. LaQue and is intended as a chapter in a book on the contribution of nickel and its alloys to chemical engineering.

Publications of Proportioneers, Inc., P. O. Box 1442, Providence 1, R.I., are indexed and described in a folder just issued. Among the items listed are bulletins on equipment and methods, and reprints and instruction manuals. A return card is included to simplify obtaining the publications desired. Ask for Bul. CAT.

(*Continued on page 96*)


"I'm one of 2000
Waterworks Superintendents
saving money through
the SIMPLICITY of
Buffalo-Made
Meters."
AMERICAN (Bronze Case) WATER METERS
NIAGARA (Galv. Iron Case) WATER METERS
Water systems in cities, towns and villages throughout the nation are saving money and increasing their revenue through the use of Buffalo AMERICAN Meters. Maintenance costs reflect the simplicity and absence of unnecessary parts, so Buffalo Meters provide full meter earnings at lowest cost per thousand gallons.
BUFFALO METER CO.
2914 MAIN STREET, BUFFALO 14, N. Y.

(*Continued from page 94*)

A test sieve shaker for sieve analysis of filter materials, chemicals, etc. has been developed by Syntron Co., 428 Lexington, Homer City, Pa., and is described in a leaflet just issued. The small, portable device is controlled by a timer and operates on 100-v., alternating current to produce an electromagnet-driven vibratory action, the amplitude of which is adjustable. The instrument accommodates six standard 8-in. sieves, and adjustable feet and a built-in spirit level permit precise leveling.

Complete, self-contained domestic water systems for shallow or deep wells are described in Bul. 50–A of the Duro Co., 537 E. Monument Ave., Dayton 1, Ohio. It might be information worth having when refusing applications for extensions to the municipal supply.

A cold-applied pipe wrapping of adhesive-treated polyethylene film is described in a bulletin on Polyken tape distributed by Plastic Engineering & Sales Corp., P. O. Box 1037, Fort Worth, Tex.

"Improved Clarification" through the use of circular collectors of the Ralph B. Carter Co., Atlantic St., Hackensack, N.J., is the theme of Bul. 4906. Engineering data, specifications, capacity tables and detailed diagrams of all three types of collectors are included.

Flow measurement bulletins just published by Fischer & Porter Co., Hatboro, Pa., include Cat. 37, "Mercury Manometer Flow Meters," and Cat. 83, "Ratosleeve Flow Meters." A catalog of glass pipe and fittings, No. 95, is also available.

"Steam Jet Deaerators" for steam power plants are the subject of Bul. W–210–B29 of Worthington Pump & Machinery Corp., Harrison, N.J.

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Cylinders are available as self-contained motor units designed to provide straight line motion for such applications as the electric or hydraulic operation of gate valves. Ledeen Mfg. Co., 1600 S. San Pedro St., Los Angeles 15, Calif., describes its lines of cylinders, rod and head attachments in Bul. 500, "Ledeen Cylinders."

A pictorial presentation of Duraplastic air-entraining cement is offered in the 20-page commemorative booklet, "A Decade of Atlas Duraplastic." Copies may be obtained from Universal Atlas Cement Co., 723 Chrysler Bldg., New York 17.

Determination of lowest power costs by quick visual check is promised by Worthington Pump & Machinery Corp. in a new bulletin, No. S-500-B-1-50, which contains a family of curves for various diesel and spark ignition gas engines. Costs are given in dollars per thousand kilowatt hours. Available from the Engine Sales Div. of the company at P. O. Box 953, Buffalo 5, N.Y.

Liquid-level recording instruments are listed and documented in an engineer's file folder compiled by Leupold & Stevens Instruments, Inc., Portland, Ore.

A valve-sizing chart for liquids and gases, covering the 0.02 to 10,000 gpm. range for liquids, has been prepared by Fischer & Porter Co., Dept. 7007, Hatboro, Pa. The chart is termed Supplement 2 to Catalog 70.

An extensive 36-page manual on hot process water softeners has been issued by Dept. 110 of Graver Water Conditioning Co., 216 W. 14th St., New York 11. The bulletin, No. WC-102, discusses boiler plant difficulties and methods of remedying them, and describes the design and operation of the two basic Graver softeners.

Section Meeting Reports

New York Section: The annual Spring Meeting of the New York Section was held at the Hotel Sheraton, Rochester, N.Y., on Thursday and Friday, March 30 and 31, 1950. One of the outstanding features of the meeting was an inspection tour of the Eastman Kodak Plant in Rochester, which was made by about 140 members. The tour was through the various departments of the plant where all branches of the film industry were seen.

Charles H. Sells, chief engineer of the State Commission on the Northwestern New York Supply, New York City, outlined in detail the new "Regional Plan for Water Supply for Northwestern New York State." This is a regional plan that covers the counties of Erie and Monroe for the eventual development of new sources of supply based on a long-term program. Anselmo F. Dappert, executive secretary of the New York State Water Pollution Control Board, Albany, presented a "Proposed System of Classes and Standards Applicable to Waters of New York State." His paper outlined very clearly the various classifications of waters suitable for various purposes, together with their chemical analyses.

Charles R. Cox, chief of the Water Supply Section in the State Dept. of Health, Albany, offered a "Current Appraisal of the Fluoridation of Public Water Supplies," based on the five-year experience record in Newburgh and Kingston, as well as other cities in the state, and a general resume of fluoridation and its effect upon teeth—a subject which is actively being considered in many sections of the country at this time.

Fred V. H. Piper, director, and J. C. Burnett, chemist, of the Niagara Falls Water Dept., ably presented their paper on "Sterilization with Chlorine Dioxide at Niagara Falls." This paper clearly described the several plans of chlorine dioxide treatment which they have followed, based on their experience record over a period of years.

A film entitled "Water—Special Delivery," was presented at the Friday morning session through the courtesy of the Elgin, Ill., Water Dept. It depicts very clearly, and in color, the activities of and methods used in Elgin, a city of about 50,000 population. The film is a very fine presentation that other sections would do well to obtain for their meetings.

(Continued on page 102)

HOW LONG is a water line?

Measure it in labor time, and you'll discover that any water supply or force main is shorter when you use ARMCO Welded Steel Pipe.

That's because ARMCO Pipe is so easy to handle and install. The whole job goes faster, smoother and more profitably. Lengths up to 50 feet mean fewer joints—there are just 106 in a mile. Even these go together quickly using standard couplers or by field welding.

You can use ARMCO Steel Pipe with complete confidence. It has a high safety factor against internal or external pressures. And the patented method of manufacture permits visual inspection of both sides of the pipe wall to guard against flaws. A spun-enamel lining assures continued high flow capacity, prevents tuberculation, stops costly cleaning.

With ARMCO Steel Pipe you can match exact job requirements—save time, labor and money. Diameters range from 6 to 36 inches; wall thicknesses from 9/64- to 1/2-inch. Write for complete data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 1205 Curtis St., Middletown, Ohio.

ARMCO WELDED STEEL PIPE

(*Continued from page 100*)

The Round Table Conference, which has developed into an annual feature, commanded the attention of practically every active member present at the meeting. The experience record on the Panel Discussion, led by S. P. Carman, consulting engineer, covered many vital topics, provoking a great deal of interest among our members and resulting in an interchange of ideas which has been of great value to them.

Through the courtesy of the Water and Sewage Works Manufacturers Assn., there was a Cocktail Hour—a regular affair at meetings for the past three years. It worked out very satisfactorily, giving many of the less well known members an opportunity to meet and exchange impressions with a number of the veteran members.

R. K. Blanchard
Secretary-Treasurer

The North Carolina Water Works Operators' School will hold its 1950 session at Chapel Hill June 4–9. Jointly sponsored by the North Carolina Section of A.W.W.A. and the N.C. Water Works Operators' Assn., the school is to be conducted this year by the Institute of Government in cooperation with the School of Public Health of the University of North Carolina. As in the past, admission is open to residents of neighboring states also.

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